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Articles

Economic Performance and Energy Intensiveness on Organic and Conventional Farms in the Corn Belt: A Preliminary Comparison

Robert Klepper, William Lockeretz, Barry Commoner, Michael Gertler, Sarah Fast, Daniel O'Leary, and Roger Blobaum

Recent energy and environmental problems in U.S. agriculture have stimulated interest in alternative technologies or systems of agricultural production. Large-scale, mechanized organic farms that use little or no inorganic fertilizers or chemical pesticides may be one such alternative. The crop production on fourteen matched pairs of organic and conventional Corn Belt farms was studied to determine the relative value of crop output, net returns, energy intensiveness, and labor requirements. The results of this preliminary study suggest that organic farming warrants more intensive research.

Key words: Corn Belt, crop production technology, energy intensiveness, organic farming.

Circumstances of the past few years have generated concern, at least in some circles, over the heavy reliance of modern agriculture on inorganic fertilizers and chemical pesticides. This concern centers on energy and environmental questions. The events of 1973 and 1974 suggest that farm income and food production are vulnerable to energy price fluctuations and shortages under circumstances previously dismissed as highly unlikely.[1] On the environmental side, in the last few years five agricultural pesticides have been removed from the market by the Environmental Protection Agency or limited to use under proscribed circumstances to forestall potential environmental damage. There is also continuing concern over the movement of fertilizer nutrients to ground and surface waters with possible eutrophication and public health consequences.

These problems have given rise to a growing interest in technologies or systems of agriculture that are less energy intensive and less vulnerable to energy price fluctuations and shortages and that have smaller adverse environmental impact. The proportion of total energy consumption accounted for by farm output is small—about 2.5% in the United States (Federal Energy Administration). Large energy savings could not be accomplished by adopting less energy-intensive technologies, but individual farmers could be made less vulnerable to fluctuations in energy prices and supply. At the same time the uncertain world food situation requires

Editor's note: This article was invited by the editor to stimulate thought, discussion, and research on the economics of organic farming.

Robert Klepper and William Lockeretz are research associates, Barry Commoner is director, and Michael Gertler, Sarah Fast, and Daniel O'Leary are research assistants at the Center for the Biology of Natural Systems, Washington University, and Roger Blobaum is an agricultural consultant in Creston, Iowa.

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[1] These unforeseen events, attributable in part to the energy crisis, include a shortage of propane for drying grain in the fall of 1973, shortages of fertilizer in the spring of 1974, and substantial increases in the prices of many agricultural inputs including increases in the prices of fertilizers relative to crop prices.

that these alternative technologies be highly productive so that world food supplies are not diminished.

One alternative agricultural system that does not rely on chemical fertilizers or pesticides is "organic farming," also known as "natural farming" or "biological farming." In this system plant nutrients are supplied through organic wastes (particularly livestock manures), leguminous green manures, purchased organic materials, and inorganic minerals such as rock phosphate that have not been chemically treated. Crop rotations also serve to reduce weed and insect problems. In some instances biological control methods are used in which beneficial insects or neutered insects are introduced into fields.

Although the term organic farming is frequently associated with small-scale, labor-intensive, subsistence farms, there are organic farmers who use essentially the same mechanized methods of crop production as their conventional counterparts but who use little or no inorganic fertilizers or chemical pesticides. We have studied the economic performance and energy consumption in the 1974 and 1975 crop years of fourteen commercial-size organic farms in the Corn Belt. Their farming methods lie near one end of a continuum of agricultural techniques of varying reliance on chemical inputs.

The purpose of the study was to determine whether organic farming warrants more intensive research. We started from the widely held premise that there is an overwhelming advantage in conventional over organic farming. The methods of analysis were matched to the problem, that is, the methods were intended to detect large differences in the performance of the two systems. If this preliminary study shows little or no difference in the two systems, further and more intensive research using more refined methods is called for. Specifically, we sought to answer the following questions in a preliminary way: Is organic farming competitive with conventional methods of crop production at the relative prices of the past few years? Is it less energy intensive? What reduction in agricultural output, if any, would result if the system was adopted to a greater degree?

The organic farming methods examined could not be adopted by all Corn Belt farmers at current prices if for no other reason than the sum of all organic wastes from farm and municipal sources falls short of the quantity necessary to meet the nutrient requirements of the present crop mix. However, the availability of livestock manures on many farms in the Corn Belt makes organic techniques or technologies that lie between organic and conventional practice an alternative for a significant portion of Corn Belt farms.[2]

In this paper the performance of fourteen organic farms is compared with the performance of an equal number of conventional farms, each of which was matched to one of the organic farms in the study. All of the organic farms raise both field crops and livestock, and each relies on livestock manure as a source of plant nutrients. As one of the criteria for matching, which are explained more fully below, the conventional farms also must have both field crops and livestock.[3] However, their performance is compared for crop production only because it is mainly in crop production that the technologies diverge. This clearly is a limitation of the study. More extensive research into organic farming should consider the farm enterprise as a whole.

Methods

No census or other comprehensive listing of organic farms exists in the Corn Belt. Consequently, it was not possible to select a random sample that represents the organic farm population. An ad hoc procedure was used to locate organic farms, primarily word of mouth. On the basis of information on location, size, length of time the farm had been operated using organic methods, a preliminary judgment of each organic farmer's competence as a farm manager, and the resources available, we chose a sample of fourteen organic farms. The organic farms chosen in this manner are a series of case studies (a judgment sample). Of course, the inability to

[2] In all the Corn Belt states, with the exception of Illinois, more than half of all the farms surveyed in the 1969 *Census of Agriculture* had as their principal source of income the raising of livestock or the production of dairy products.

[3] We deliberately chose matched conventional farms that have livestock rather than cash grain farms. The supply of manure on these farms and their need for roughages in cattle-feeding programs makes the adoption of organic methods easier on purely technical grounds than would be the case for a cash grain farm. At the same time, their relatively heavy reliance on inorganic fertilizers and pesticides clearly differentiates their technology from that of the organic farms in this study.

statistically sample limits the extent to which inferences from the results can be made to a larger population of Corn Belt farms. Under the circumstances, this was unavoidable.

The organic farms are operated as family enterprises by full-time farmers. The total acreage of each farm lies within a range of 175 to 800 acres. They are widely distributed over the central and western portions of the Corn Belt. Four are located in Iowa, four in Illinois, and two each in southern Minnesota, northern Missouri, and eastern Nebraska. Each had been farmed organically for four or more years prior to 1974. All the farms have one or more of the following forms of livestock: beef cow herd, cattle on feed, hogs, dairy cattle, or sheep.

On the organically farmed land in the study, none of the farmers used inorganic nitrogen fertilizer or urea, acidulated phosphates (e.g., triple superphosphate), or, with one exception, conventional potassium fertilizer (muriate of potash). Some used commercial organic fertilizers, phosphate rock, or powdered rock containing trace minerals.[4] No insecticides are used on any of these farms, and in all but one case no herbicides are used. In all cases but one, the farms had previously been operated using at least some inorganic fertilizers and pesticides, generally with an intensiveness comparable to the majority of similar farms in the area.[5] The average length of time over which the farms were managed organically was six years prior to the start of the study.

A nearby conventional farm was selected as a match for each organic farm. This farm was required to raise both crops and livestock and to be as similar to the organic farm as the matching procedure allowed in soil type, size, and livestock inventories. Conventional farms that met or came close to meeting these criteria were located with the assistance of the staff members of county offices of the Agricultural Stabilization and Conservation Service (ASCS), who in most cases consulted with the local Soil Conservation Service (SCS) office before making recommendations. In addition we asked that all recommended farmers be "top management" operators as judged by local ASCS personnel. We did not have a measure of the managerial ability of the organic sample, but we had no reason to believe they are superior managers when taken as a group. The management criterion was applied to the conventional group to avoid biasing the results toward the organic farmers. Since the management criterion was applied together with other criteria on size, soils, and mix of operations, the extent to which the management criterion was met is not clear. Indirect evidence is presented below in the form of data on yields and fertilizer use by the conventional farmers in the sample. The lack of detailed soil maps in most of the counties in which the sample farms lie, the highly qualitative requirement for managerial ability, and the multiple criteria on which the matching took place made the matching procedure largely qualitative. The limitations of the matching procedure leave considerable room for within-pair differences in organic and conventional farms. Some indications of the success of the matching are given below.

Data were collected for each farm for the 1974 and 1975 crop years. Data for the 1974 crop year were collected in personal interviews of both groups of farmers in late winter and early spring of 1975. The data for the 1975 crop year were collected by means of questionnaires mailed to the farmers and returned by mail. For both crop years the following data were collected for each field: (*a*) crop(s) and yield(s); (*b*) application rates and costs of all fertilizers, pesticides, lime, and other materials; (*c*) application rates of manure; (*d*) tillage, planting, cultivation, and harvesting operations; and (*e*) seed variety, price, and seeding rate. Cropland for the crop year in question is all land that was ever in crops in the preceding five years; that is, it includes land in row crops and small grains, land in rotation pasture or hay in rotation with row crops or small grains, and land unharvested in that crop year. Land in permanent pasture or continuous hay is not cropland by this definition, nor, of course, is land in feedlots or woodlots or land associated with farm buildings.

Three measures were computed for com-

[4] There are many commercial organic fertilizers on the market. Most of these are proprietary products for which little or no information is available on the process by which they are produced or on their content aside from the required statement on nitrogen, phosphorus, and potassium content. We have not verified their authenticity as organic products, nor have we attempted to determine their content.

[5] Four of the organic farmers in this study rent additional cropland and use inorganic fertilizers and chemical pesticides on it under the terms of a rental agreement. In addition, in 1975 three of the organic farmers used a chemical of one sort or another on small portions of their own land. These fields were excluded from the analyses.

paring the relative performance of the farms in the study: the value of crop output per acre of cropland, a net return to cropping activity measure that accounts for most variable costs (fixed costs are discussed below), and the energy intensiveness of crop production measured in British thermal units (BTU's) per dollar of crop output and BTU's per acre.

We relied on farmer's reported yields, verified where possible by elevator receipts and consistency with storage facilities filled and sales. Because a large proportion of crops are fed to livestock on many farms, reported yields frequently could not be corroborated. Therefore, the yield data are subject to inaccuracies and possible bias. Crops were valued at statewide season average prices received by farmers (USDA June 1975–Jan. 1976).[6] These values in turn were aggregated over all crops and divided by cropland acres to obtain the value of crop output per acre of cropland.[7] Although some organic farmers sell their crops in specialty markets as organic grain and receive a premium, they were not credited with the premium. Season average prices were used to value the crops of both groups of farmers regardless of whether the crops were sold or consumed by livestock on the farm.

The net returns per cropland acre measure is the value of crop output per acre of cropland minus most variable costs per acre. Fixed costs are assumed not to differ between the two groups. There is evidence that this assumption is reasonable. The largest fixed costs associated with crop production for Corn Belt farms of the kind in this study are the value of land for its use in crop production; depreciation on machinery, equipment, and storage facilities used in crop production; and property taxes and interest on debt. Data on the estimated cash rental value of the cropland in each group, which are presented in the next section, suggest that no substantial error is introduced by assuming that the cost of land is the same for the two groups, although there is considerable variation within pairs. If this is so, then there would be no large difference in the property taxes on land imposed on each group for a uniform tax rate and assessment procedure. The data collected showed that the organic and conventional groups differed little in the type and size of machinery and equipment they owned and used for field operations,[8] although the number of pieces of equipment varied with the size of the farming operation, as one would expect. This suggests that depreciation on machinery and equipment did not vary greatly between the two groups. The conventional farmers had more high moisture grain storage facilities, but these differences were too small to be the source of significant differences in fixed costs. The roughly equal values for land, machinery and equipment, and grain storage facilities between the two groups suggest that little difference in interest expenses would exist if both groups have access to capital markets on the same terms.

The variable costs included in this study are the reported or imputed values for seed; fertilizers; pesticides; soil amendments; crop drying; and the fuel, lubrication, labor, and repairs associated with all tillage, planting, cultivation, material application (including manure spreading), harvesting, and on-farm crop hauling operations in the crop year.[9] Those excluded are rent (all farmers were treated as if they owned all the land they farmed), crop insurance, and the share attributable to crop production of each of the following: sales and social security taxes, workman's compensation and disability insurance, bookkeeping and office supplies, electricity, telephone, vehicle licenses and all

[6] For 1975 we first developed an average of monthly prices through January 1976, from which were estimated the averages for the entire crop year using historical patterns of seasonal variation.

[7] Where two crops were obtained from a single field in a crop year, e.g., soybeans after winter wheat or hay after a small grain nurse crop, the value of both crops was included. Yields for rotation pasture and hay crops grazed by livestock were computed in animal units from farmer's reports of the number and kind of animals grazing and the duration of grazing; one animal unit month of grazing was valued at one-fourth the season average price for one ton of hay.

[8] For example, the median horse power of the largest tractor owned was 89 and 94, respectively, for the organic and conventional groups. All farmers in each group had a row crop planter of at least four rows. Twenty-one percent of the organic farmers and 18% of the conventional farmers had row crop planters of more than four rows. About one-third of each group owns a combine with a corn head of more than two rows. However, the two groups do vary with respect to their preference for moldboard or chisel plows. One hundred percent of the organic group versus 50% of the conventional group use a chisel plow. A moldboard plow is used by 86% of the conventional group and by only 29% of the organic group.

[9] In addition, prorated costs of lime and other soil amendments that were applied less frequently than annually were included, as were the prorated costs of establishing rotation pastures and hay stands for stands lasting more than one year. Costs for the establishment of green manure crops that were plowed down prior to planting in a crop year were also included.

expenses for vehicles used for general purposes, and subscriptions and memberships.

For the purposes of computing the costs of crop production, we assumed that there are no differences between farmers and between the two groups in certain aspects of raising crops. The price per unit of standard inputs such as pesticides, propane for drying, diesel fuel, and gasoline were assumed to be equal for all farmers in the study for a given crop year. Fertilizer prices were assumed equal for all farmers in a state. (These data were taken from the USDA's *Agricultural Prices*, April, July, August, and October issues, 1974–75.) Each farmer's reports of the quantity of particular fertilizers and pesticides applied were valued at the standard prices. Other inputs such as organic fertilizers purchased by organic farmers and hybrid seed were valued at the prices reported by the farmers in the study.

Because the characteristics of the machinery and equipment owned and used for field operations differed little between the two groups, for any given field operation the same tractor and implement were assumed to be used on all farms and labor requirements and cost per acre for that operation, including the imputed cost of labor, were assumed to be the same for all farmers in the study in a crop year.[10] All farmers were assumed to harvest a particular crop with the same equipment and to have the same cost schedule where costs per acre vary with yield. The sole exception is that the distinction between harvesting corn on the ear with a corn picker or as grain with a combine was preserved.[11] Again, allowance was made for differences between years in the prices used to build up the cost estimates. The costs of on-farm hauling of crops were also standardized with respect to the truck or equipment used and the distance hauled in taking a particular crop out of the field to on-farm storage or to the farm gate.

The energy calculations were made using coefficients previously derived for specific operations, such as chisel plowing or grain drying, and for agricultural chemicals that are manufactured by energy-consuming processes.[12] Details of the derivations of these coefficients can be found in Commoner et al.; what follows is a brief summary.

Fuel requirements for drying, tilling, planting, cultivating, and harvesting operations were obtained by combining many different estimates from a wide variety of experiment station and extension service publications and personal communications, taking account of differences in the conditions under which individual values were measured. As in the estimates of the cost of field operations described above, each individual operation was assumed done with the same tractor and equipment complement on each farm, and the same energy coefficient was applied in the calculations for each farm using a particular operation. No adjustment was made for differences in soil type or soil moisture at the time of the operation. Fuel requirements for harvesting operations and hauling do vary by crop and yield in this study. Fuel used for drying was assumed to be liquid petroleum gas on all farms. A constant value was used for the liquid petroleum gas required to reduce the moisture content of a bushel of grain by 1%. This value was applied to the farmers' reported yield and moisture content at harvest. To calculate the fuel and energy requirements for drying, 85% of the corn was assumed dried to a final moisture content of 15.5%. As in the cost of drying, farmers who harvested and stored ear corn were charged the energy requirements for shelling and drying.

The indirect consumption of energy by farmers through fertilizers was calculated from reported application rates and energy coefficients derived for both the extraction and benefication of minerals and the process energy used in production of nitrogen, phosphorus, and potassium fertilizers. Compendia of chemical engineering and mining process-

[10] While no difference in costs and labor requirements for a particular field operation is assumed between farmers in the study, the costs and labor requirements of all field operations for a crop do differ between farmers according to the combinations of field operations each farmer reported used. If a farmer made more trips over his fields in preparing the ground for seeding, in cultivating to control weeds, or in manure spreading, he would show higher costs and labor requirments for field operations in the calculations.

[11] All corn, whether harvested as ear corn or corn grain, was assumed to be shelled and dried to 15.5% moisture, the standard for No. 2 corn grain. The cost of drying was computed as the product of a standardized cost for a percentage point of moisture and the difference between the reported moisture at harvest and 15.5%.

[12] Energy coefficients were developed in a number of studies of energy use for particular crops or for agricultural production as a whole (Hirst, Pimentel et al., Steinhart and Steinhart). But we chose to develop our own coefficients in 1974 because the coefficients existing at that time were either dated or based on processes that were not always representative of conditions in this country.

es, standard references on specific fertilizer industries, reports on individual processes, and unpublished data from the Sulfur Institute were the sources of data from which these coefficients were derived. The energy required to transport the fertilizer from factory to farm is small relative to the energy required in processing and manufacture and was ignored. Estimates were also made of the energy requirements for mining and processing lime and gypsum. A standard energy coefficient per hundredweight was used for all commerical organic fertilizers. This was based on personal communications with several organic fertilizer producers and the assumption that other organic fertilizers have similarly small energy requirements.

The great variety of pesticides used precluded careful estimates of the energy coefficients for each. An estimate of the energy input per pound of DDT was used with application rates to determine energy consumption. Although DDT is no longer used in U.S. agriculture, it is representative of an important class (chlorinated hydrocarbons) of both insecticides and herbicides. Indirect energy consumption in the form of pesticides is small relative to that in fertilizers and fuel, so that errors arising from this simplifying assumption are likely to be small when compared with total energy use on a conventional farm.

Effectiveness of the Matching Procedure

Some indications of the success of the matching procedure follow. The mean total farm size of the fourteen organic farms was 429 acres (ranging from 175 to 844 acres) and 479 acres for the fourteen conventional farms (range 171 to 849 acres). Acreage in cropland differs more between the two groups; the mean was 250 acres for the organic farms (range 113 to 420) and 348 acres for the conventional farms (range 124 to 769).[13] The mean livestock inventory in animal units was 101 and 63, respectively, for the organic and conventional groups in the 1975 crop year, and machinery and equipment do not differ greatly between the two groups (see note 8).

In addition, we asked two and sometimes three persons who are knowledgeable about local agricultural conditions in each county where the sample farms lie and who know the sample farms in that county to estimate the cash rental value of the cropland in the sample farms. These persons were usually the head of the local ASCS office, the extension agent, a Federal Land Bank official, or the head of the local SCS office. For each pair of farms the estimates of both farms were provided by the same person, except in three cases where the farms in a pair were in neighboring counties. The average estimated cash rental value of cropland was \$68 for the organic group and \$66 for the conventional group. The interquartile range was \$51 to \$74 and \$53 to \$83 for the two groups, respectively.

There is no reason to believe that overall the matched conventional and organic farms systematically differ in the productivity of their cropland or the characteristics of their machinery and equipment complements. Furthermore, the conventional farms in the sample appear to be typical of conventional farms in general in that they differ little from average statewide fertilization rates for major crops, and they apply herbicides and insecticides at rates that appear to be within the range of typical practices in the Corn Belt. Average fertilization rates for corn, soybeans, and wheat for the conventional sample in 1974 are presented in table 1. A weighted average statewide fertilization rate for each crop is given in the same table. These data show the conventional farmers to be close to the statewide average for each crop. The fact that they all have livestock and may apply

Table 1. Average Fertilization Rates, Conventional Sample, and All Farms in Same States, 1974

Crop	Conventional Sample	All Farms[a]
Corn	101-53-71	108-61-63
Soybeans	8-38-40	13-44-66
Wheat	53-67-57	55-61-53

[a] All rates are pounds N, P_2O_5, and K_2O per acre receiving fertilizer. Weighted average of statewide average fertilization rates. The weighting factor for each state is the number of farms in the conventional sample in that state on which fertilizer is used on the particular crop.

[13] On average the organic group has a smaller proportion of farm land in crops. There are several reasons for this. First, some members of the organic group farm additional cropland with chemicals, as explained above in note 5, and this land is not part of their "farm" for the purposes of this study. Second, the organic farms have more permanent pasture; they also have more grazing livestock.

some manure to these crops should be taken into consideration in interpreting the table.

Results

Although the two groups of farmers raise the same major crops, they do so in different rotations, so that they differ in the proportion of their cropland in each crop in a given year. As seen from table 2, corn (grain and silage) is the leading crop on both groups of farms; however, because of the importance of hay and pasture in organic rotations, row crops (corn and soybeans) average only 52% of cropland in the organic sample compared to an average of 73% on the conventional farms. Small grains are more prevalent on the organic farms because these crops are generally raised as nurse crops for new stands of hay or pasture.

Table 3 shows the yields obtained by the two groups of farms in 1974 and 1975. Because this table is intended to indicate how the two groups compared in yields, it is restricted to farms in which both members of a particular pair raised a particular crop. The clearest difference between the two groups is in corn grain, for which the conventional group had higher yields. Differences in wheat (1975) and hay (1974 and 1975) may be less meaningful because there were so few farms growing these crops.

Table 3 shows that, in general, yields improved in 1975 and that the advantage of the conventional group over the organic group was stronger in 1975. These are understandable consequences of the different weather patterns. In 1974, virtually every farm in our study was adversely affected by weather. In 1975, a few of the farms were affected by drought, but conditions were good for a large portion of the sample. Consequently, yields were appreciably better. The better relative performance of the conventional farms under these conditions might reflect the greater response in yields to nutrient availability at the margin when weather conditions are favorable.

Table 2. Average Fraction of Cropland in Various Crops by Type of Farm, 1975 and 1974

	Organic		Conventional	
Crop	1975	1974	1975	1974
	---------- % ----------			
Corn grain	25	24	39	35
Corn silage	6	8	4	6
Soybeans	21	21	31	31
Wheat	9	6	7	7
Oats	11	12	6	5
Hay or pasture[a]	25	25	12	15
Other[b]	3	5	3	4
Total[c]	100	101	102	103

[a] Established stands only.
[b] Includes milo, rye, barley, buckwheat, and new meadow seedings other than with nurse crop. (New seedings with nurse crop included under particular small grain.)
[c] Total greater than 100% because of double cropping.

Table 3. Average Yields by Type of Farm, 1975 and 1974[a]

	Organic		Conventional		Number of Pairs Raising Crop	
Crop	1975	1974	1975	1974	1975	1974
Corn grain	74	74	94	76	14	11
Soybeans	35	32	38	29	12	11
Wheat	28	28	38	29	4	4
Oats	58	56	60	60	5	5
Hay[b]	4.5	5.0	3.9	3.4	4	6

[a] Only for farms in which both members of matched pair raised the crop. Yields are bushel per harvested acre, except hay in tons per acre.
[b] Established stands only, used only for hay. (Stands that were partially cut and partially grazed are excluded.)

The yields obtained by all farms in this study, regardless of whether the matched farm in a pair raised the crop, are shown in table 4. In this case, the average yields of the two samples should not be compared to each other, since they reflect different portions of our study area. Rather, each group's yields were compared with the average yields obtained by all farmers in the same counties as the farmers in the sample who raise the crop. The conventional group did about as well as the population in general in 1974 and considerably better in 1975. The organic farmers did better than farmers in general in soybeans in both years and poorer in wheat and corn in 1975. In other cases, they did about the same or better than farmers in general.

Table 5 shows the average and median value of all crops produced on each type of farm expressed as the value per acre of cropland. The higher value of production on the conventional farms reflects two factors: the somewhat higher yields, especially for corn,[14] and the higher proportion of cropland

[14] The value of crop output per acre is not particularly sensitive to the yields reported by farmers for any one crop. For

Table 4. Average Yields for Both Samples and for All Farms in Same Counties

Crop	Year	Organic Sample	All Farms[a]	Conventional Sample	All Farms
Corn	1975	74 (n = 14)	90[b]	94 (n = 14)	88[b]
	1974	74 (n = 11)	75	71 (n = 14)	73
Soybeans	1975	34 (n = 13)	30	38 (n = 12)	31
	1974	32 (n = 11)	25	28 (n = 12)	25
Wheat	1975	26 (n = 9)	38	41 (n = 5)	36
	1974	28 (n = 7)	31	29 (n = 6)	29
Oats	1975	56 (n = 8)	NA	57 (n = 7)	NA
	1974	59 (n = 9)	55	59 (n = 6)	59

[a] Average of countywide average yields for the counties for which a farm in the particular sample raised the particular crop (USDA).
[b] "All Farms" data for corn differ slightly for the two samples because of three pairs in which farms were in adjacent counties.

in high value crops, especially corn and soybeans. The average and median value of crop output was higher on the conventional farms than on the organic farms in both years. The ratio of the value of crop output of the conventional to the organic group rose less between 1974 and 1975 than relative crop yields because corn and soybean prices declined somewhat in 1975, whereas the prices of roughages increased. This change favored the organic group because of their crop mix. In the past few years, both crop prices and weather conditions have been extremely variable in the Corn Belt, and future fluctuations in both will have important implications for the economic performance of the two kinds of farms we are studying.

Data on the variable costs included in the study for both groups, averaged over all cropland, are shown in table 5. Apart from general inflation in input prices, there were no significant changes from 1974 to 1975 in the overall average level or range of operating costs in the two samples. The difference in mean production costs ($19 per acre averaged over the two years) results primarily from the fertilizers and pesticides purchased by the conventional farmers (Lockeretz et al. 1975).

The difference between the value of crop output and variable costs, denoted here as crop production returns, is also shown in table 5. This measure was almost equal for the two groups in both years. As with the value of crop output, there is considerable variation within each sample, particularly the organic group. Because of this variation, and because of the sampling procedure mentioned earlier, table 5 should not be regarded as implying more than a qualitative relation between crop production returns on the entire populations of the two kinds of farms in

example, if organic farmers uniformly reported corn yields 20% higher than actual corn yields, then the average value of crop output per acre for the organic group would be biased upward by about 5%.

Table 5. Average and Median Market Value of Crops Produced, Operating Costs, and Crop Production Returns per Acre of Cropland

	Value of Crops ($/A)		Operating Costs ($/A)		Crop Production Returns ($/A)	
Year	Organic	Conventional	Organic	Conventional	Organic	Conventional
1975						
Mean	169	193	34	54	135	140
Median	169	179	33	44	133	136
Interquartile range	132–194	171–194	29–41	42–58	109–156	119–143
1974						
Mean	159	172	28	46	131	127
Median	150	167	30	45	123	122
Interquartile range	141–190	140–203	20–34	38–53	107–154	101–141
Two-year average						
Mean	164	183	31	50	133	133
Median	160	173	32	45	128	129
Interquartile range	136–183	159–201	23–33	39–53	106–143	114–148

Table 6. Selected Measures of the Energy Intensiveness of Crop Production by Type of Farm, 1975 and 1974

	Organic		Conventional	
1,000 BTU Per	1975	1974	1975	1974
Crop output ($)	6.6	7.2	15.0	17.3
Crop acre	1,092	1,116	2,819	2,983
Corn (bu.)	19.8	29.5	56.0	80.8
Soybeans (bu.)	32.6	34.7	27.4	51.4

the Midwest. It indicates only that this quantity on average is probably not very different between the two populations and could, of course, be very different between an individual farm of each type.

Various measures of the energy intensiveness of the two groups of farmers are shown in table 6. Whether energy intensiveness is measured in thousands of BTU's per dollar of crop output or thousands of BTU's per acre of cropland, in both years the conventional group was more than two times as energy intensive as the organic group. The main source of the difference between the two groups is the use of inorganic fertilizers, particularly nitrogen, by the conventional group. A contributory factor is the greater proportion of cropland in corn on conventional farms, which is more energy intensive than hay crops or small grains even apart from its fertilizer requirements, since it also requires propane for drying and a relatively large amount of fuel for field operations (Lockeretz et al. 1976).

Table 6 also presents measures of energy intensiveness for two crops, corn and soybeans, in thousands of BTU's per bushel of crop output. In the two years the conventional group was 2.7 to 2.8 times as energy intensive in raising corn. For soybeans the difference between the two groups was less pronounced; the conventional group was more energy intensive than the organic group in 1974, and the reverse was true in 1975. This change reflects the increase in soybean yields for the conventional relative to the organic group between 1974 and 1975 and a shift from slightly less to slightly more energy use per acre of soybeans for the organic group relative to the conventional group.

Table 7 shows the distribution of manure applications over various crops and the average application rates to those crops in the 1975 crop year. Manure spreading was a common practice on both groups of farms. The two groups were fairly similar in the prevalence of manure spreading, application rates, and the fraction of land receiving manure. However, from the information in this table and information above on acreage in cropland and animal units, one can see that the conventional group applied more manure to cropland although they had fewer animal units. This reflects the higher proportion of confined livestock on the conventional farms and the greater tendency of the organic group to keep livestock on temporary pasture or keep them in lots with access to pasture land. No data were collected on the nutrient content of the manure spread.

Finally, a calculation of the labor requirements for crop production in 1975 shows slightly higher labor requirements for the

Table 7. Livestock Manure Applications by Type of Farm, 1975 Crop Year

	Organic				Conventional			
	Number of Farms				Number of Farms			
Crop	Growing Crop	Applying Manure to Crop[a]	Area in Crop Receiving Manure (%)[b]	Application Rate (tons/acre)[c]	Growing Crop	Applying Manure to Crop[a]	Area in Crop Receiving Manure (%)[b]	Application Rate (tons/acre)[c]
Corn for grain	14	7	64	8.2	14	7	54	9.1
Corn for silage	6	4	89	6.8	7	4	79	10.3
Soybeans	13	5	56	8.8	12	2	61	8.0
Hay	14	4	51	6.0	10	1	100	7.3
All crops	14	10	28	8.4	14	9	28	9.3

[a] Excludes cases in which manure is applied to less than 5% of land in indicated crop.
[b] Average for farms in which at least part of the crop received manure.
[c] Weight as applied. Average for land receiving any manure.

organic group: 3.3 hours per acre for the organic farmers versus 3.2 hours for the conventional farmers or 19.8 hours per $1,000 of crop output for the organic farmers versus 17.8 hours for the conventional group.[15] The difference is more pronounced when expressed as labor input per dollar of crop output because the value of crop output per acre is lower for the organic group. A similar comparison of labor requirements for major crops shows equal average labor requirements for both groups for corn (3.8 hours per acre) and small grains (1.9 hours per acre). The organic group had a somewhat greater labor input for soybeans: 3.8 hours per acre versus 2.6 for the conventional group.

Conclusions

The results of this study are preliminary and largely qualitative. The organic farms produced somewhat less crop output per acre of cropland than their conventional counterparts; however, the variable costs of crop production per acre were higher for the conventional group. If fixed costs per acre did not differ between the two groups as assumed, then the net returns to crop production were about the same for the two groups. The organic group used considerably less energy per dollar of crop output and per acre of cropland and had slightly greater labor input per acre. By these measures the organic group appears to be doing reasonably well despite the fact that they do not use many of the chemical inputs that are generally regarded as key elements in the productivity and prosperity of modern agriculture.

Throughout this paper returns to cropping activity have been expressed in dollars per acre of cropland. A more relevant measure is returns to the whole farm enterprise, but this question cannot be addressed with these data. For crop production alone, the two groups had the same average gross returns minus variable costs per acre of cropland and, since the conventional group had an average of 39% more cropland per farm, their returns minus variable costs from crop production were also an average of 39% higher or 25% when adjusted for the difference in the average total size of the two samples. This calculation does not include income from grazing on permanent pasture. Because of the different ratio of cropland to total land in the two samples, as well as differences in livestock inventories, one cannot infer from these results that organic farming lowers the returns to crop production as a whole or to the whole farm enterprise, including livestock production. A determination of whether land is being put to its highest and best use in both groups of farms and a study of the joint crop-livestock enterprise would be required to answer these questions.

In the absence of a complete characterization of the land on each farm, one cannot assume a priori that the two groups are working with the same proportions of various kinds of land and are merely using that land differently. On the other hand, crop rotations that include hay are an integral part of the technology of organic farming, and this may limit organic farms to certain kinds of livestock operations and certain combinations of cropland and permanent pasture. Over time farmers have some control over the quantity of various kinds of land farmed within the constraints imposed by the availability of land and capital. Given this flexibility, the multiple uses to which land of a given quality may be put, and the unknown combinations of cropland and permanent pasture that are economic under the constraints of the technology of an organic farm, we presently have insufficient information to choose between three plausible explanations for the differing ratio of cropland to total size between the conventional and organic groups: (*a*) the two groups actually are similar in the characteristics of their land, but the organic farmers have to use some cropland as permanent pasture; (*b*) the two groups actually are similar in the characteristics of their land, but the conventional farmers are cropping land that the organic farmers consider more suitable as permanent pasture because it is subject to considerable erosion when cropped; or (*c*) the two groups differ in the character-

[15] The calculation is based on a uniform equipment and machinery complement representative of the kinds prevalent in both samples. As mentioned above, the two groups are very similar in the equipment they use. Since these groups were matched at least roughly by type of soil, a given operation, when performed by the hypothesized standard equipment, is assumed to take the same length of time on both groups of farms. In other words, results are intended to show the relative labor requirements of the two cropping systems under given soil conditions and with equipment of a given size and are not necessarily accurate in an absolute sense. Furthermore, the calculations deal only with labor required directly in crop production. No allowance is made for trips to town, general farm business, marketing, etc.

istics of their land, and the different cropland to total size ratios reflect appropriate land use in each case; e.g., the organic farmers need more permanent pasture and have acquired land that is best used as pasture.

Clearly, further analysis of land use on the two kinds of farms is necessary in comparing the two farming systems. Given this limitation of the present study, no basis exists for expressing crop returns data in terms of the entire farm. We have reported results on the basis of an acre of cropland, with cropland defined in terms of how the land is actually used. Additional data are needed on the land in each farm and the interaction of crop and livestock activities on organic farms before the two systems can be compared on a whole farm basis.

Other limitations should also be emphasized. We only compare farms that are mixed crop-livestock enterprises, and these are limited to the Corn Belt; the study has no implications for cash grain farming in the Corn Belt or farming of any kind in other regions. The number of farms studied was quite small, and the data are from only two crop years. Weather in 1975 was fairly typical of Corn Belt conditions, except for drought in the western portion of the study area, but the weather in 1974 was unfavorable for nearly every farm in the study. The organic farms studied had used organic methods for at least five years. Farms in transition from conventional to organic methods may encounter short-term fertility problems, since nutrients supplied in organic form are not as readily available as those in inorganic fertilizers. The extent to which the farms in this study import nutrients in the form of purchased feed was not calculated. In addition, organic farmers may be the recipients of positive or negative externalities associated with the insect and weed control practices of their conventional neighbors.

Even within the limits of the data collected for this study, there may be errors. The samples may not accurately represent the larger populations of farms from which they are drawn as a result of the manner in which they were selected. Errors may arise from reliance on farmers' reports of yields, field operations, purchased inputs, and other data used in the calculations. Also, the matching of conventional to organic farms was fairly crude. Therefore, the data cannot be used to infer the consequences of a significant portion of Corn Belt farms switching to organic methods, nor can they be used to predict the consequences of a switch to organic methods for an individual farm.

In addition, there are questions that relate to the long-run viability of both systems of farming such as nutrient balance, soil loss through erosion, and the organic matter content of the soil. We have begun research on some of these long-run questions but do not address those issues here.

These results, limited and qualitative as they are, suggest that further research is warranted into organic methods of crop production as well as methods that lie between the conventional and organic alternatives. Increased research effort on such alternatives, including controlled experiments, may ultimately yield high returns by increasing the range of acceptable and competitive methods for modern crop production and by facilitating the substitution of appropriate alternative methods in response to changing environmental regulations and energy prices.

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Controlling Nonpoint Sediment Sources with Cropland Management: A National Economic Assessment

James C. Wade and Earl O. Heady

Utilization of cropland resources is one of the primary determinants of stream sediment water quality. The management of cropland is one way to improve sediment water quality. Models of the economics and physics of sediment provide insights into the agricultural production system and potential requirements for improved water quality. The application of such a model provides an assessment of the fundamental changes that might be required to accomplish reduced sediment loads through cropland management. The hypothetical water quality policies analyzed give insights into several possible sediment water quality policies.

Key words: land use, large-scale modeling, nonpoint pollution, sediment.

Sediment in streams is the most abundant of all U.S. water pollutants. Its impacts are widespread, and its controls are interwoven with land use and land use policy. Sediment causes pollutant damages estimated as high as $1 billion annually (Stall; Holt, Johnson, and McDowell). In addition, damages not directly accounted for by the market system include fish and wildlife environments, water recreation, and river and lake aesthetics overcome by sediment deposits. The damage process is so old that many view it as natural (Beasley).

This study is an evaluation of a modeling scheme designed to link demand for agricultural commodities to generation of cropland sediment (Wade). The evaluation takes the form of comparing five alternative policies to control sediment in the rivers and streams of the United States. The alternatives are designed to display the flexibility and limitations of U.S. agriculture in meeting environmental restraints placed on nonpoint sediment under a fixed set of demands for agricultural products.

James C. Wade is an assistant professor of agricultural economics, University of Arizona, and Earl O. Heady is a Curtiss Distinguished Professor of agriculture, a professor of economics, and the director of the Center for Agricultural and Rural Development, Iowa State University.

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The Problem

The intensive cropping systems of the United States resulting from the technical transformation of agriculture utilize lands in an ever increasing number of ways. Intensive cropping practices resulting from the substitution of capital inputs for labor has resulted in increased application of chemicals to cropland in the forms of fertilizers and pesticides. The residuals of some of these chemicals combine with eroded soil and water runoff from cropland to pollute many of the streams of the United States (Beasley; Holt, Johnson, and McDowell). Simultaneous goals of meeting domestic and foreign food and fiber demands and meeting rising demands for a quality environment are forcing changes on the structure of agriculture. In viewing sediment from eroded cropland soils and its associated chemical pollutants as a residual of cropland management, environmental quality improvement may be attained by changing the use of land, the technologies applied to the land, and the crops produced on it. The process viewed as a local problem has many simultaneous interregional and na-

tional implications. The changes in agricultural crop production in one region of the country to meet water quality demands require adjustments in production technologies not only in that region but also in other regions to provide the demanded agricultural products. The adjustments in the agricultural production system that result from national environmental quality sediment goals are the concern of this study.

The Model

The model used in analyzing the national and interregional impacts of sediment water quality on the agricultural system is described in equations (1) through (8):

$$\min Z = c'x \tag{1}$$

subject to

$$Ax \leq b, \tag{2}$$

$$Bx \geq d, \tag{3}$$

$$Sx - Dx_D \leq s^*, \tag{4}$$

$$x_D - Tx_T \leq 0, \tag{5}$$

$$x \geq 0, \tag{6}$$

$$0 \leq x_D \leq r_D, \tag{7}$$

$$0 \leq x_T \leq r_T, \tag{8}$$

where x is commodity and sediment production vector, c is production costs vector, A is resource requirements matrix, b is resource limits vector, d is commodity demands vector, B is commodity output transformation matrix, S is soil loss matrix, x_D is sediment delivery vector, x_T is sediment transport vector, D is sediment delivery ratios matrix, T is sediment transport ratios matrix, r_D is restraint vector on delivery sediment, r_T is restraint vector on transported sediment, and s^* is a vector of erosion from noncropland sources.

This statement of the model is simplified to express its central elements without giving complexity to each component involved. Detailed descriptions may be found elsewhere (Wade, Meister and Nicol).

Individual sections of the model can be described in simple terms. Equation (1) is the total cost function for agricultural production. It includes costs for crop and livestock production and for commodity transportation among the various regions of the United States. Equation (2) is the resource transformation matrix system, which converts the resource vector (b) into the agricultural commodities demanded through equation (3) from the final demand vector (d). Both resources and commodity demands are regionally differentiated. Equation (4) is the sediment delivery relationship that determines the quantity of sediment moving from each subriver basin. The transport of sediment among the subriver basins modeled is represented in equation (5). Equation (6) represents nonnegativity in production of agricultural commodities. Finally, equations (7) and (8) represent environmental restraints on sediment delivery and transport from the various regions. Some additional details about the various sections of the model are given in the following paragraphs.

The Production Sector

The basic commodity production and transportation systems of this model were developed as an analytical tool for use in the National Water Assessment for the Economic Research Service, U.S. Department of Agriculture, and the Water Resources Council and are specifically described elsewhere (Meister and Nicol, Wade). For this presentation, however, a brief verbal description of the production mechanisms will provide a background for the analysis that follows.

In this model crop production occurs in each of the 105 producing areas, each of which is made up of nine land quality classes. Each region is provided activities that produce crops occurring historically in the producing area.[1] The crop commodities produced by such activities are shipped interregionally to meet the demands of each of twenty-eight market regions (Meister and Nicol). Production technologies available in each producing area include a range of crop rotations, tillage practices, and conservation practices for each soil class.[2] Crop production activities require land, water (for irrigated activities in the western states), nitrogen fertilizer, and operating costs as inputs. Each activity produces an average yield of the crops in the rotation based on the technical

[1] Endogenous crops are barley, corn grain, corn silage, cotton, lint and seed, legume hays, nonlegume hays, oats, sorghum grain, sorghum silage, soybeans, sugar beets, and wheat. Resources for the production of all other crops are preallocated in each producing area.

[2] Tillage practices are conventional tillage residue removed, conventional tillage residue left, and minimum or reduced tillage. Conservation practices are straight row, contour, strip, and terrace cropping.

and cultural practices and the characteristics of the producing area and residual soil loss based on regional climatic and soil conditions. Nitrogen carry-over is computed for nitrogen-fixing crops. The soil loss for each activity is computed using the Universal Soil Loss Equation (Wischmeier and Smith) and data provided by the Soil Conservation Service (Nicol). Costs for producing one acre of a cropping activity consider crop yields, the tillage and conservation practices used, and the producing area in which production occurs.

Livestock production, defined at the market region level, includes dairy, hogs, beef cows, and beef feeding, which provide five commodities: milk, pork, beef feeders, fed beef, and nonfed beef.[3] Various ration alternatives are used in each market region to transform feed inputs into livestock outputs at lowest cost. All technologies and feed conversion rates for the crop and livestock production are projected to year 2000. Production costs are computed based on 1972 average input costs in each producing area, assuming that relative input costs will remain unchanged to year 2000. Although this assumption is somewhat limiting, the inability to estimate potential long-term changes in price relationships makes this assumption as good as any other and gives a sound base for comparison of results in the modeled system (Meister and Nicol).

[3] Other livestock and poultry production is allocated based on historic production levels. The demands for feed inputs are computed and added to total market region demand.

Demand and Market Sector

National demands for the various commodities of the model are based on a projected national population of 264.3 million in 2000 as shown in table 1. Regional distribution of population among the market regions and export levels are set as in the National Water Assessment model (Meister and Nicol, U.S. Water Resources Council). The commodities—corn grain, barley, oats, oilmeal (from soybeans and cotton), sorghum grain, wheat, milk, pork, beef feeders, fed beef, and nonfed beef—are shipped among the market regions to meet consumer and export demands, while cotton lint and beet sugar are consumed nationally. Hay crops and silage (from corn and sorghum) are consumed within the market region of production as required by the livestock production systems and exogenous livestock.

Table 1. National Commodity Demands for National Sediment Model Year 2000

Commodity	Consumption Demand[a]	Other Uses and Supplies[a]	Export Demand	Feed Demand for Exogenous Livestock	Total Demand for Endogenous and Exogenous Commodities[a]
			Million Units		
Barley (bu.)	13.1	205.7	35.0	86.2	340.0
Corn (bu.)	343.4	287.1	2,069.0	1,096.2	3,793.9
Oats (bu.)	55.8	48.5	21.0	43.2	168.4
Grain sorghum (bu.)		15.2	380.0	203.6	598.8
Wheat (bu.)	613.4	89.7	919.0	47.8	1,669.9
Oilmeal (cwt.)	−22.6	271.5	700.6	344.1	1,287.5
Fed beef (cwt.)	268.9		−26.3	6.6	242.5
Nonfed beef (cwt.)	126.5		−2.9		123.6
Milk (cwt.)	1,197.9		−10.4		1,187.5
Pork (cwt.)	187.6		−3.5		184.1
Cotton (bales)	6.6		4.2		10.8
Sugar (tons)					39.9
Nonlegume hay (tons)		−154.5		6.6	−147.9
Sheep and lambs (cwt.)					1,720.1
Turkeys (lbs.)					3,438.2
Broilers (lbs.)					15,076.3
Eggs (doz.)					6,365.9
Other (units)					30.0

Source: Meister and Nicol.

[a] Negative numbers indicate net supplies exogenous to the model.

Sediment and Erosion Sector

Three types of erosion sources are considered in this study. First, erosion from cropland used in production is determined as the sum of the soil loss from all cropping activities in each producing area. Second, soil loss is computed from croplands not used in crop production. Finally, erosion from all noncropland sources is fixed since managing of noncropland is not possible under the assumed model. The total erosion from noncropland sources includes estimates for gully, stream bed, and channel erosion. The procedures used to determine the erosion rates are described in detail in other publications (Wade, Wade and Heady).

The movement of eroded soil from its original resting place to the stream system is a process called sediment delivery. Sediment delivery is assumed in this study to be a fixed proportion of the total gross soil loss from all sources within each producing area, both fixed and variable (cropland). The sediment delivered from each producing area joins the sediment delivered from other producing areas in a flow pattern that simulates the river system of the United States. The eighteen major river basins serve as summary regions for data analysis of the model solutions.

The sediment delivery and transport system described previously in equations (4) and (5) is expressed for the ith producing area by equations (9) through (11). Sediment delivery from the ith producing area is

$$(9)\quad D_i\Big[\sum_j \sum_k S_{ijk}X_{ijk} + s_i^* + \sum_j SA_{ij}XA_{ij}\Big] = XD_i,$$

where X_{ijk} is acres of production activity k on land quality class j, S_{ijk} is tons per acre of gross soil loss from activity k on land quality class j, s_j^* is tons of gross soil loss for land uses not endogenous to the model, XA_{ij} is acres of unused cropland in land quality class j, SA_{ij} is tons per acre of gross soil loss from unused cropland of class j, D_i is proportion of gross soil loss that reaches the stream, and XD_i is tons of suspended sediment delivered.

Similarly, sediment transported for the ith producing area that has sediment flow-through is

$$(10)\quad T_i\Big[\sum_{l\to i} XD_l + \sum_{k\to i} XT_k\Big] = XT_i,$$

where XD_l is sediment delivered from the lth upstream producing area directly, XT_k is sediment transported through an upstream producing area k into the stream producing area l, T_i is proportion of sediment moved to producing area i's boundary, which is transported through producing area j, and XT_i is sediment transported.[4] Finally, the total sediment load ($XS_{i'}$) at the outflow of each river basin is

$$(11)\quad XS_{i'} = XT_{i'} + XD_{i'},$$

where $XS_{i'}$ is the sum of sediment delivered from the sediment transported through the last (or ith) producing area of the river basin.

This formulation of the erosion and sediment delivery system requires the computation of sediment delivery and transport coefficients (see Wade for details of coefficient development). The sediment delivery coefficients vary substantially among the producing areas with the highest ratios of 32.2% and 37.8% of eroded soil delivered to the stream system occurring in a subarea of the Upper Missouri River Basin and the Klamath River of northern California. Low sediment delivery ratios of less than 1% of the total sediment delivered to the stream occur in several areas of the country but dominate in areas of the southeastern states and in some high mountain areas. Since these coefficients are estimated from historic data, the differences in geographic, geologic, and economic make-up of each region should be reflected in each coefficient. Similarly, the sediment transport ratios are estimated for each producing area that has upstream rivers flowing through. These coefficients vary from 100% for river segments like the Lower Mississippi, which is channelized with few sediment trapping areas, to 0.1% for area river segments like the Lower Tennessee River, which has a series of large reservoirs. Coefficients for the middle parts of the Mississippi River, which has numerous locks and dams, range from 40% to 70% of the sediment load transported through the region.

Converting equations (9) through (11) into linear restraints and adding them to the linear programming production model described previously gives the link between agricultural land management and sediment loads as a water quality variable.

[4] The symbolism $l \to i$ and $k \to i$ means "for all l (or k) contributing directly to i."

Concept of Alternative Futures

The formulation of an analysis procedure that incorporates a normative model potentially produces some misunderstandings. The normative model of national cost minimization creates a diversion from current reality as short-term restriction imposed by various institutional and physical restraints are ignored to view more fundamental long-term relationships. Obviously, in a model such as the one presented here, some variables that are extremely important in the short run are omitted and, thus, assumed perfectly flexible in the long run. For example, regional restraints on available labor and capital are not included in this model, as these variables are assumed to be completely mobile between the present and the year 2000. Utilizing the year 2000 allows enough time for the long-term changes necessary to establish a new economic equilibrium to take place.

Formulation and examination of alternative policies in this type of framework are considered as an analysis of alternative prospects for the future (or alternative futures), remembering that the model is only an approximation of reality and not reality. This is particularly a problem in a model that formulates an evaluation procedure that combines economic and physical data. One must remember that the relationships are casual but, as such, are a first-order approximation of a problem more often viewed as either a physical or an economic problem but not both.

The solutions presented in this paper represent a set of five alternative futures. Comparing these alternatives to the past or the present serves only to confuse, since by its normative nature and long-run assumptions the model will not approximate either. Comparisons of alternative futures must be made among a set of alternative futures with only informal looks at the past. These looks back serve as guideposts and intuitive points of departure. Analysis of alternative futures examines the departure of those futures that incorporate policy alternatives from the unrestricted future.

Policy models are neither forecasts nor predictions. They are analytical tools for assessing the possible impacts of variations in policy. In the analysis that follows we analyze five alternatives in such a manner.

Solutions Analyzed

Five national sediment control policies were evaluated using this model. Each examined the changes in U.S. agriculture resulting from the regulation of sediment loads. An unrestricted alternative was run with no restraints placed on sediment movement or loads in the stream system. This solution provides a base for comparison with alternatives where sediment restraints are imposed. A second alternative minimizes the total national sediment load and total production cost,[5] which is accomplished in two computer runs by first running the model to minimize the total national sediment load. The minimum sediment load is then used as an upper limit on total national sediment load (and also as a lower limit), while total cost is minimized. Thus, minimum sediment loads at minimum cost are obtained. The minimum sediment alternative provides an extreme environmental restraint where maximum stream quality is obtained while meeting prespecified consumer demands. This policy is used only for comparison purposes and is not proposed as a practical or administratively feasible alternative.

The third alternative examines the effects of a policy that restricts the average annual soil loss allowed per acre for each producing area and soil class. Production technologies for each soil class having average soil loss rates that exceed the maximum level allowable to conserve the soil and maintain its productive capacity are eliminated from the set of technologies available for crop production. Limiting soil loss in this manner removes many of the low cost but non-soil conserving practices that would otherwise be used. This policy, the T-limit alternative, is a simulation of the Iowa Conservancy Law applied to the forty-eight contiguous states. The T-limit alternative as applied in the Iowa legislation requires farmers who have gross annual cropland soil loss higher than the maximum allowed in their county to initiate operations to improve the soil loss condition. The legislation also required that federal subsidy funds be available to help the farmer provide the conservation treatments needed. With the reduced availability of funds and

[5] Total national sediment load is the sediment loads flowing from all rivers into the ocean and countries surrounding the United States.

the general policing problem, the legislation has had little affect on farming operation. If such a policy is to be applied on a national scale, the problems of policing and subsidation would have to be overcome.[6]

The fourth alternative is the PA-limit alternative, which restrains sediment loads from cropland for each producing area to 20% less than the unrestricted alternative. This solution examines some of the potential variations in location of production and technical management of cropland that would reduce sediment load.

Although this alternative does not express a currently proposed alternative, the types of alterations in management of cropland can be related to a set of policies that could be supported by water quality and farming interest. Once a target level is established for sediment loads in the rivers or streams flowing from each subbasin or producing area, land use goals or practices can be induced by providing cost sharing funds to producers under stipulations that such funds be used in a prescribed manner or by establishing a taxing scheme for eroded soil moving from the land and into the stream system.

Determining such tax rates is a highly information-intensive operation. Establishing tax rate or penalties for eroded farm land could be based on research materials concerning soil loss and sediment transport in water. Neither data presented in this report nor most other currently available are adequate for making such judgments. A considerable amount of additional research would be required to integrate the physical and policy concepts. Subsidization programs could be similar to already existing small watershed projects that combine land use change and stream impoundments to reduce sediment problems. The water quality management program would be increased to administrative areas conforming to subbasins or producing areas and the much broader water quality goals.

[6] The Iowa Conservancy Law was initiated to control erosion and conserve cropland farming potential. However, by keeping soil on the cropland, such a program also reduces the movement of sediment into the stream system. The law is administered by local conservancy boards who hear complaints from adversely affected parties and make judgments on improvements required to reduce damage to the cropland and to adversely affected parties (generally, neighbors upon whom sediment is washed). Actual soil loss rates are based on the research materials presented in Wischmeier and Smith, while the allowable rates are determined considering the maximum rate at which soil can be lost without affecting the productivity of the soil (Iowa Cooperative Extension Service).

Finally, a river basin limit alternative requires a 20% reduction in the sediment loads from cropland below the unrestricted alternative at each river basin outflow rather than at the producing area level. This policy is similar to the PA-limit alternative except that the regions of concern are much larger. To enforce such policies, a group similar to the River Basin Commissions would be required. Such agencies would have to have interstate power to examine policy goals and to provide the guidelines for meeting the goals. The results of this analysis provide insights into some of the required guidelines, which would have to be expanded into more specific regional policy statements by such a commission. Once such goals and guidelines are established, either a policing or incentives type administration could be used to obtain required objectives. Since policing is very costly and is politically unpopular, the latter approach seems more feasible. The guiding group or agency could use differentiated policies among the various subbasins within the basin to obtain desired water quality goals.

Results

Sediment Loads

Table 2 presents the sediment outflows of the eighteen major river basins of the United States for each of the five alternatives. These outflows are compared with the estimated average annual sediment loads for 1960–69 to varify the general magnitude of the simulated sediment loads of the unrestricted alternative. The sediment loads for the unrestricted alternative compare with the estimated average loads (see Curtis, Culberson, and Chase) except for a few notable cases where cropping patterns are significantly different in the year 2000 than at the present. For example, sediment loads of the Upper Mississippi River and Missouri River basins differ substantially from the average historic values. However, the combined flows moving from the Mississippi River do not differ greatly from historic values. Two distinct mechanisms create the differences in these two river basins. First, the use of reduced tillage cropping practices in the Upper Mississippi River Basin reduces the erosion substantially even in the unrestricted alternative. In the Missouri River Basin the large acreage

Table 2. Sediment Loads from Average Historic Data and the Five Sediment Control Alternatives

River Basin	Average Historic Sediment Loads[a] (1,000 tons)	Sediment Load for Alternatives of Sediment Control (1,000 tons)				
		Unrestricted (Base Solution)	Minimum Sediment	T-Limit	PA-Limit	River Basin Limit
New England	1,760[b]	1,703	1,528	1,661	1,667	1,666
Mid-Atlantic	4,807[b]	4,355	3,790	4,086	4,223	4,223
S. Atlantic-Gulf	12,916[b]	11,298	10,150	10,416	11,007	11,006
Great Lakes	—[c]	6,895	4,839	5,991	6,433	6,433
Ohio	58,800	51,535	43,029	47,065	49,602	49,602
Tennessee	18,400	13,200	11,128	11,990	12,706	12,706
Upper Mississippi	181,000	120,593	69,213	90,710	109,757	107,403
Lower Mississippi	344,000[b]	309,641	226,332	274,462	291,240	291,240
Souris-red-rainy	1,770[b]	1,018	533	903	897	897
Missouri	20,380	106,184	62,899	81,367	97,145	92,216
Ark.-white-red	32,186	27,495	22,789	24,853	26,444	26,443
Texas-Gulf	18,542[b]	12,543	9,644	11,534	11,933	11,932
Rio Grande	275[b]	1,206	1,138	1,249	1,189	1,190
Upper Colorado	31,655	28,871	28,439	28,867	28,776	28,776
Lower Colorado	97[b]	2,119	2,082	2,107	2,111	2,111
Great Basin	—[c]	5,342	5,091	5,323	5,288	5,289
Col.-N. Pacific	18,467[b]	15,468	11,594	15,393	14,657	14,658
California	42,717[b]	44,233	42,354	44,127	43,818	43,818
Total sediment outflow	432,435	415,024	318,297	376,451	393,671	393,665

[a] Average historic sediment loads are the sums of available sediment outflows from the river basin as computed from average historic data. Sources are detailed in Wade.
[b] Used to compute total sediment outflow to the oceans surrounding the United States.
[c] Not available.

of unused cropland erodes at higher than average rates, producing more residual than if the land were cropped. This rate assumes that cropland is simply dropped from production and that no attempts are made to maintain the soil of the uncropped land. In the long run, some areas would revert to natural vegetation reducing the soil loss from unused land. However, in many parts of the country without conscious programs to revegetate such lands, erosion rates would be very high.

The total sediment outflow from the United States approximates the historic average value as do most of the sediment loads of the individual river basins. The sediment loads for the unrestricted alternative provide a basis for comparison as restraints are placed on sediment loads. For the minimum sediment alternative, sediment loads are reduced sizably as the national total load is reduced. The total sediment load is reduced by 23.3% from the unrestricted alternative. This reduction is complicated by the fact that 308.3 million tons of the total sediment load originate from noncropland sources and cannot be altered by changing cropland use. The agricultural portion of the sediment load is reduced by 90.6% from the unrestricted to the minimum sediment alternative.

The impact of noncropland sources of erosion varies among the river basins. The largest proportion of total erosion from noncropland sources is in southwestern United States, where between 93.1% and 98.3% of the total unrestricted alternative's sediment loads are from noncropland. In contrast, in the Midwest larger proportions are from cropland sources. Although this result is not surprising, it is extremely important that the regional differences in the impact of potential land use policy are directed solely at cropland management.

The T-limit alternative, which restricts cropping methods available to farmers to those that produce no more than maximum soil loss level, results in sizable changes in sediment load for most river basins. The highly erosive areas of the Midwest and Southeast have sharply reduced sediment loads. The cropping areas of the West are less restrained since rainfall is low and thus soil loss from cropland is much less than in other areas. Some areas of the West actually

show an increase in sediment loads as cropping adjustments necessary to meet commodity demands are made. The national total sediment load decreases to 376.5 million tons per year, a 9.3% reduction from the base solution.

The PA-limit alternative offers a third environmental alternative obtained by requiring a reduction in the sediment load of each subriver basin or producing area without restricting the technologies. This alternative results in a 5.1% national reduction in sediment loads as compared to the base solution. This national reduction occurs as each river basin's load is reduced and each affected subbasin limit works its way through the river system. The river basins with the largest reductions are naturally those that have the largest proportion of cropland sediment sources. Thus, the sediment loads do not substantially change in the Southwest where cropland contributions are small.

Sediment loads for the river basin limit alternative are almost identical to those of the PA-limit alternative, producing only a 5.1% reduction in national sediment load. However, since the restrictions on sediment loads are placed at the river basin level rather than the producing area level, major differences occur in the use of the land and the cost of sediment load reductions.

Land Use

One of the keys to the control of sediment as a nonpoint source of pollution is the use to which cropland is placed. Cropland is the management tool in this evaluation of sediment loads, since land use is a determinant of the soil loss and eventually the sediment load of each region. An analysis of four primary areas of cropland use are briefly described below: tillage practice, conservation practice, crop type, and total use. These variables are summarized in table 3 for the year 2000.

Land use for the minimum sediment alternative is significantly changed from the unrestricted alternative. The most noticeable change is in the use of reduced tillage technologies and terracing practices to reduce soil loss. Other significant changes include increases in close-grown hay crops.

Table 3. National Total Acres of Cropland by Conservation and Tillage Treatments and by Crop Type for the Alternatives for Sediment Control

Land Use	Alternatives for Sediment Control				
	Unrestricted	Minimum Sediment	T-Limit	PA-Limit	River Basin Limit
	1,000 acres				
Straight row[a]	94,097	65,666	63,396	80,019	81,898
Contour tillage residue removed	30,044	24,222	20,668	27,112	29,364
Contour tillage residue left	35,810	16,314	17,452	28,964	32,611
Reduced tillage	28,243	25,130	25,276	23,943	19,923
Contour cropping[a]	112,380	126,911	111,002	109,509	107,351
Contour tillage residue removed	7,003	17,663	7,884	7,638	6,976
Contour tillage residue left	55,078	21,760	46,388	48,691	44,861
Reduced tillage	50,299	87,488	56,730	53,180	55,514
Strip cropping[a]	68,684	5,831	61,740	81,879	83,385
Contour tillage residue removed	5,924	2,070	4,572	8,382	6,547
Contour tillage residue left	27,665	3,524	25,510	34,314	36,383
Reduced tillage	35,095	237	31,658	39,183	40,455
Terracing[a]	33,642	164,370	74,503	44,315	35,677
Contour tillage residue removed	5,337	12,880	13,632	6,324	5,841
Contour tillage residue left	26,329	37,751	45,645	35,053	28,221
Reduced tillage	1,976	113,739	15,226	2,938	1,615
Total cropland[a]	308,803	362,778	310,641	315,722	308,311
Unused cropland	55,550	1,575	53,713	48,630	56,042
Crop type					
Row	187,085	183,379	186,281	185,056	186,562
Close grown	58,220	77,659	60,111	62,789	57,935
All hay	52,239	99,460	56,916	54,015	52,287
Summer fallow	11,205	2,286	7,338	13,869	11,534

[a] Totals may not add because of computer rounding.

Such changes require additional total acreage to produce the commodities demanded. Terracing acreages increase by a dramatic 389.3% over the unrestricted alternative. These extreme environmental restrictions also alter production systems and the location of primary production. Significant increases in economic advantage are noted in the western river basins.

Similar but less dramatic changes are required in land use for the T-limit alternative. Terracing acres increase by 121.7% over the unrestricted alternative, while reduced tillage acreage increases only 11.5%, compared to the 90.6% increase in the minimum sediment alternative. Rather small changes in land use are noted between the unrestricted alternative and the producing area and river basin limit alternatives. The changes in land use for the PA-limit alternative reflect the impositions of restraints at levels that demand change within each producing area without regard to similar changes that may be occurring in other producing areas of the same river basin. In the river basin limit alternative, intrabasin trade-offs in production are utilized to balance required water quality changes. Thus, river basin level summaries do not fully express the location changes in production that occur to meet environmental changes. In the PA-limit alternative sediment loads decrease almost uniformly for all producing areas, since the restraints are placed at the producing area level. These decreases are from 1% to 20%, depending on the proportion of the total land area cropped. For the river basin limit alternative, the sediment loads increase in some producing areas and decrease in others, since some producing areas that are at a comparative economic advantage produce crops intensively. In these areas, total erosion increases, while conservation and tillage practices are used to reduce sediment loads in other areas of the same river basin. This adjustment process utilizes some producing areas as "water quality management areas," and the total river basin sediment load is reduced at lower cost than in the PA-limit alternative. Thus, although on a producing area level cropland use is changed markedly, this change is not reflected in the river basin level sediment loads of table 1.

Sediment loads for each producing area vary in the river basin limit alternative. Changes in sediment load from the unrestricted alternative range from small increases in several areas to greater than 40% changes in other areas. While many of the crop-producing areas of the Midwest and Great Plains are essentially unchanged from the unrestricted alternative, producing areas in the same river basin decrease substantially to meet the river basin level restraint. In the Upper Mississippi River Basin, Great Basin, and Upper and Lower Colorado River basins, sediment loads in each producing area are reduced a small amount (less than 1%) to reduce the river basin sediment load to the required level. Utilization of croplands determine these changes in sediment loads.

Crop composition differs considerably between the unrestricted and minimum sediment alternative as illustrated in tables 4 and 5. Production of row crops, although rather stable in acreage, changes in composition under the minimum sediment alternative as more corn and sorghum grain are produced and less (almost no) silage is raised, since silage production removes crop residue and increases erosion. To augment grain inputs in the livestock-feeding system, increased hay and small grain acreages are used for feed.

Cost of Sediment Control

One of the primary items of concern in analyzing potential environmental policy is the evaluation of costs sustained by farmers and by society. Table 6 presents differences in total national cost of meeting consumer demands under the several alternatives.[7]

The costs of producing the total bill of goods assume a fixed final demand for commodities, which creates some difficulty under the extreme variations of this model since consumer demands are not fixed as prices change. In the context of analyzing sediment control policy, fixed commodity demands are a limitation to this type of model. The exact division of the cost of sediment control among consumers, producers, and society as an institution is unclear. The costs of table 4 represent the change in the total (private plus social) costs under the assumed policies. The costs of the various alternatives could be represented by changes in marginal cost of producing each commodity or as the social

[7] Total cost is the cost of producing and transporting all crop and livestock commodities endogenous to this national model exclusive of land rent.

Table 4. Acreage for Major Crops by River Basin for the Unrestricted Alternative

River Basin	Barley	Corn Grain	Cotton	Hay[a]	Oats	Silage[b]	Sorghum Grain	Soy-bean	Sugar Beets	Wheat
	1,000 acres									
New England	0	0	0	234	58	159	0	0	0	0
Mid-Atlantic	912	1,691	0	1,073	19	254	0	1,246	0	2,535
S. Atlantic-Gulf	0	1,488	2,321	769	340	1,179	0	10,320	0	1,361
Great Lakes	459	9,199	0	1,344	462	266	0	4,656	1,741	1,200
Ohio	1,175	9,391	0	1,434	3	221	0	12,359	0	1,626
Tennessee	0	65	0	194	0	0	0	2,010	0	0
Upper Miss.	0	26,610	0	4,500	468	136	223	24,709	0	268
Lower Miss.	0	45	2,498	1,677	85	538	0	10,537	0	1,330
Souris-red-rainy	562	2,983	0	0	0	0	0	3,157	0	9,082
Missouri	3,534	2,456	0	20,812	4,588	8,830	6,115	7,375	153	10,727
Ark.-white-red	220	734	805	11,007	344	5,160	3,433	5,770	0	7,725
Texas-Gulf	0	205	21	3,440	406	4,683	5,291	2,219	0	1,579
Rio Grande	103	566	0	293	0	278	0	0	0	2
Upper Colorado	62	0	0	364	0	417	0	0	0	30
Lower Colorado	38	0	105	430	0	332	41	0	0	53
Great Basin	89	0	0	386	0	247	0	0	0	518
Col.-N. Pacific	104	0	0	2,467	0	523	0	0	0	5,243
California	468	296	123	1,815	0	904	0	0	0	446
U.S. total[c]	7,726	55,729	5,873	52,239	6,772	24,129	15,103	84,358	1,894	43,722

[a] Total of legume and nonlegume hays.
[b] Total of sorghum and corn silage.
[c] Total may not add because of computer rounding.

subsidies required to maintain the marginal cost of the unrestricted alternative or both. In the T-limit alternative, the marginal cost of producing the commodities follows a normal pattern of increasing as returns to land among the farmers increases and a long-run adjustment is made by a somewhat natural market adjustment, and all cost changes can be passed on to consumers. When regional restraints on sediment loads are imposed, such as the minimum sediment, PA-limit, and river basin limit alternatives, numerous

Table 5. Acreages for Major Crops by River Basin for the Minimum Sediment Alternative

River Basin	Barley	Corn Grain	Cotton	Hay[a]	Oats	Silage[b]	Sorghum Grain	Soy-beans	Sugar Beets	Wheat
	1,000 acres									
New England	0	0	0	879	165	1	0	0	0	0
Mid-Atlantic	916	1,360	0	3,677	568	0	0	1,684	0	215
S. Atlantic-Gulf	0	3,239	0	2,841	520	199	0	12,139	0	116
Great Lakes	0	6,642	0	5,486	1,064	0	0	4,139	518	3,164
Ohio	422	7,864	0	3,257	399	0	0	8,331	0	8,242
Tennessee	0	1,382	0	920	0	0	0	575	0	397
Upper Miss.	0	25,253	0	7,794	4,042	0	0	16,784	0	6,401
Lower Miss.	0	1,489	0	7,634	1,490	0	0	5,873	0	1,781
Souris-red-rainy	0	8,422	0	2,429	2,385	0	0	5,267	0	0
Missouri	7,847	19,675	0	33,345	2,435	541	3,791	8,890	449	12,964
Ark.-white-red	111	377	22	10,234	970	1,458	10,371	10,799	187	7,379
Texas-Gulf	0	439	6,143	10,086	185	0	1,414	2,495	0	1,687
Rio Grande	219	138	278	970	34	97	456	0	0	20
Upper Colorado	90	39	0	357	0	361	0	0	33	289
Lower Colorado	0	0	158	761	0	5	3	0	0	244
Great Basin	267	0	232	1,148	0	0	0	0	170	277
Col.-N. Pacific	391	93	0	5,581	786	230	0	0	243	7,539
California	914	0	2,438	2,064	0	11	110	0	68	725
U.S. total[c]	11,176	76,413	9,272	99,460	15,043	2,008	16,144	76,977	1,669	1,440

[a] Total of legume and nonlegume hays.
[b] Total of corn and sorghum silages.
[c] Totals may not add due to computer rounding.

Table 6. Total Annual Cost of Producing and Transporting Commodities for the Five Sediment Control Alternatives

	Unrestricted	Minimum Sediment	T-Limit	PA-Limit	River Basin Limit
Total cost (million $)	31,932	45,332	32,863	32,034	31,958
Increase in total cost (million $)	—	13,400	931	102	26
Index of total cost	100.0	142.2	102.9	100.3	100.1
National sediment load (million tons)	415.0	318.3	376.4	393.7	393.7
Decrease in sediment load (million tons)	—	106.7	38.6	21.3	21.3
Index of total land	100.0	76.7	90.7	94.9	94.9

inefficiencies are forced into the production system as farm practices are forced to meet stream sediment quality requirements. Cropland is used at levels other than at marginal rates of return, and losses are incurred by producers in some areas and not in others. These losses result in decreased marginal costs for most commodities and decreased long-run consumer costs. If society is going to support such policies, the losses of the farmers would need to be compensated to provide income parity and a continued strong farm sector. The results are lower food cost to consumers and higher environmental budget cost to entice a pattern of land use that will meet prespecified sediment water quality goals. The question of who pays depends on the policy and how it is administered.

For the minimum sediment alternative, total costs increase by 42.2% above the unrestricted alternative or $13.4 billion annually. This extreme environmental control provides a 23.2% reduction in total sediment load. The T-limit alternative has total costs of $931 million, 2.9% less than under the unrestricted alternative. The corresponding reduction in total sediment load of 9.3% is large relative to the total cost change.

In the PA-limit and river basin limit alternatives, total cost changes are small, only 0.3% and 0.1%, respectively, relative to the unrestricted alternative. However, both obtain a 5.1% reduction in total sediment load. In these two cases, the point of application of the restraint is extremely critical in determining total cost. As illustrated in table 2, almost identical sediment loads are obtained by the two at both the river basin and national levels. Obviously, at the more detailed level of the producing areas, much more variation is shown in sediment load.

Limitations

This model is limited in its ability to duplicate the total environment of sediment water quality policy. As a linear programming model, it suffers some of the typical restrictions on such models. The limited response of the demand sector to variations in marginal production cost limits the analysis in that the specific consumer commodity demands and environmental policies analyzed are not simultaneous. This same problem exists to some extent for the production sector as variations in production will obviously change the demand structure for production inputs. Input prices are assumed to maintain the same relative input costs. The marginal cost of the commodities must, therefore, be considered as relative costs to be compared with cost of other alternative futures. On the physical side of the model the representation of the sediment system is an elementary approximation that may introduce irregularities into the policy analysis and formulation. For example, estimation of soil loss rates are not uniformly accurate across the United States, and the procedure for estimating sediment delivery and transport ratios are at best crude. These are first-order approximations of the variables of sediment water quality and, like all other variables and assumptions of this model, if in error may seriously modify the findings of this study. However, they may also point toward a better understanding of the physical research needed to augment policy decisions and, in doing so,

point biological, physical, and economic researchers toward new areas of cooperative research.

Conclusions

The alternatives examined in this analysis give no best sediment control policy. Clearly, the minimum sediment alternative requires extreme changes in the production system that increase total production cost greatly. This solution requires many interregional changes to accomplish sediment goals. However, the principle burden falls on the Mississippi River drainage area where the potential erosion control is greatest. In this alternative, as in all of the others, erosion from noncropland sources exceeds that from cropland sources. Cropland remains a major source of sediment, and cropland management offers a means for improvement in water quality.

The T-limit alternative places controls at the farm level and increases both the average and marginal costs of the commodities produced. It also results in a substantial reduction in total sediment load. Regional erosion differences are recognized by this type of control and economic advantages change accordingly. If a higher level of sediment control is desired, this type of policy might prove difficult to administer.

The final two alternatives, the PA-limit and the river basin limit alternatives, do not provide a large change in the national sediment load. They do, however, provide some insight into the type of variation in sediment loads and production cost expected under the two alternative levels of administrative control.

The optimum policy of sediment control based on cropland management can only be determined by evaluating society's goals relating to food costs, environmental quality, farmer decision freedom, and other dimensions of resource use. The use of large-scale models, such as the one outlined in this study, to design policy might substantially reduce the costs of policy choices to society by anticipating the interactions and costs of such policies. To the extent that such models are improperly formulated, policy implications may be wrongly stated. In any event, additional information provided by policy modeling is a needed input for policy formulation.

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The Welfare Effects of Erosion Controls, Banning Pesticides, and Limiting Fertilizer Application in the Corn Belt

C. Robert Taylor and Klaus K. Frohberg

The partial welfare effects of alternative erosion control methods, banning insecticides, banning herbicides, and limiting nitrogen fertilizer in the Corn Belt are examined. The estimated welfare effects are partial since they reflect the change in consumers' plus producers' surplus arising from the production and consumption of corn, soybeans, wheat, oats, hay, and pasture but not the environmental benefits associated with pollution abatement or the administrative and enforcement cost of the policies. A large linear programming model of crop production in the Corn Belt was used to make the estimates.

Key words: Corn Belt, erosion, linear programming, models, nitrogen fertilizer, pesticides, pollution.

The 1972 Federal Water Pollution Control Act mandates the development and implementation of controls of agricultural nonpoint sources of water pollution (U.S. Congress). The primary responsibility for carrying out this mandate rests with state governments, with the Environmental Protection Agency's (EPA's) role being one of seeing that this is done in a satisfactory manner. The EPA currently believes that in many cases the goals of the act can be carried out by applying practicable best management practices, including conservation practices that prevent or mitigate entry in the nation's water of diffuse-source substances that tend to degrade those waters. In those cases where applications of these management measures are inadequate to attain or maintain water quality, the EPA intends for more vigorous controls to be implemented (Pisano, p. 11). If the goal of the act that "the discharge of pollutants into the navigable waters be eliminated by 1985" is strictly interpreted, the more vigorous controls seem likely for many agricultural nonpoint sources (U.S. Congress, section 101.a).

This article presents estimates of the partial welfare effects of the following public policies related to agricultural pollution in the Corn Belt: (*a*) a ban on the use of herbicides; (*b*) a ban on the use of all insecticides; (*c*) nitrogen fertilizer restrictions of 100 and 50 pounds per acre; (*d*) no straight row cultivation; (*e*) gross soil loss restrictions of two, three, four, and five tons per acre; (*f*) terracing subsidies at annualized rates of \$5, \$10, \$15, \$20, and \$40 per acre; and (*g*) gross soil loss taxes of \$4, \$2, \$1, and \$0.50 per ton. The pesticide and nitrogen policies, while extreme, are plausible under a strict interpretation of the 1985 water quality goals that are set out in the amended 1972 Federal Water Pollution Control Act. The pesticide regulations that are presently under consideration by the EPA and states will not significantly affect the crops considered here and were not evaluated. Illinois, the only Corn Belt state to seriously consider limiting fertilizer use, has determined that nitrates are not presently a problem and has recommended that controls

C. Robert Taylor is an assistant professor of agricultural economics, Texas A&M University, and Klaus K. Frohberg is a research assistant in agricultural economics, University of Illinois.

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not be instituted at this time. But since some water supplies to the state exceed the controversial U.S. Public Health Service standard for nitrates, this issue is by no means resolved. The magnitude of the nitrate problem in other states is not well known. Erosion-sedimentation controls are much more likely to be implemented than pesticide bans and fertilizer restrictions and therefore constitute the practical thrust of this article.

While the primary responsibility for nonpoint source management rests with states, the federal government retains the authority to impose more stringent requirements. Furthermore, the EPA is charged with encouraging uniform state laws relating to the prevention, reduction, and elimination of pollution (U.S. Congress, section 103.a). For these reasons and also because of the large number of conceivable policies that differ by state or region, this analysis focuses on regionwide policies.

The estimated effects are partial in the sense that they reflect the change in consumers' and producers' surplus arising from the production and consumption of the major crops but not the environmental benefits associated with pollution abatement or the administrative and enforcement cost of the policies.

The Model

The model used for this analysis is a linear programming model of the production and marketing of corn, soybeans, wheat, oats, hay, and pasture in the Corn Belt. The production of cotton and soybeans in this area accounts for about 70% and 60%, respectively, of the total U.S. production of these commodities.

The objective function of the model is consumers' plus producers' surplus in the corn and soybean markets minus the total variable costs of producing a specified amount of small grains, hay, and pasture. As is well known, the maximization of surplus gives a competitive equilibrium solution (Takayama and Judge).

The demand functions for corn and soybeans are incorporated into the model in a stepwise fashion, with steps in 2¢ increments. The demand functions used in the model are

$$(1) \quad Q^c = 5{,}613{,}712{,}245 - 763{,}775{,}100P^c$$

and

$$Q^s = 1{,}469{,}981{,}594 - 130{,}224{,}637P^s,$$

where Q^c and Q^s are the bushels of corn and soybeans demanded, respectively, and P^c and P^s are the per bushel prices. At the mean, the elasticity of demand for corn is -0.50, and the corresponding figure for soybeans is -0.64. These demand functions were subjectively specified after reviewing recent demand analyses (Houck, Ryan, and Subotnik; Vandenborre; Brandow; Rojko, Urban, and Naive). The quantities of wheat, oats, hay, and pasture demanded were treated as constants in the model because these are relatively minor crops in the area and also because the inclusion of stepped demand functions for them would have increased the size of the model to the point where the cost of obtaining a solution would have been prohibitive.[1] Fixing the quantities demanded of the minor crops causes a slight over or under (depending on the policy) estimation of the change in surplus resulting from the policies.[2]

The land base for the area modeled was divided into eleven land capability units (LCU's) within each of seventeen geographical regions that are land resource areas (LRA's) defined by the Soil Conservation Service (SCS) (USDA 1975). Crop production activities in the model differ by crop rotation (an average of about eleven rotations for each LCU within each LRA), conservation practices (straight row, contouring, and terracing), and tillage methods (fall plow, spring plow, and chisel plow). Rotations rather than just single crop activities are

[1] Hay and pasture account for about 27% of the acreage in the area. In the benchmark model solution as well as in actuality, hay and pasture are primarily produced on LCU's that are unsuitable or marginally suitable for row crop production. To the extent that wheat and oats are grown to diversify production and reduce risk, the inclusion of their production in the model as constraints is reasonable. The quantity of hay and pasture that had to be produced was specified by LRA, while the quantity of wheat and oats demanded was specified for the whole Corn Belt area.

[2] The change in consumers' surplus (ΔCS) was defined to be

$$\Delta CS = \sum_{i=1}^{6} \Delta CS_i,$$

where ΔCS_i is the change in consumers' surplus for the ith crop, with $CS_i = (P_{Bi} - P_{Ri})(Q_{Bi} + Q_{Ri})/2$, where i is corn or soybeans and $CS_i = (P_{Bi} - P_{Ri})Q_{Bi}$ where i is wheat, oats, hay, or pasture, P_{Bi} is price for crop i in bench run, P_{Ri} is price in model run for the policy under consideration, Q_{Bi} is quantity demanded for crop i in bench run, and Q_{Ri} is quantity demanded in model run for the policy under consideration.

included in the model to reflect the influence of the previous crop on the fertilizer and pesticide requirements of the current crop.

A simplified matrix representation of the model is given in table 1. The first column of this matrix represents 14,542 crop production activities. The vector C represents the per acre variable production costs exclusive of labor and fertilizer, while the vectors Y^c, Y^s, Y^w, Y^o, and Y^h give the yields associated with each activity. Each production activity takes one acre of land from the appropriate LRA and LCU (see row 11) in the appropriate LRA and LCU. The vector *nsc* gives the carry-over nitrogen supplied by soybeans to corn in a rotation. The vectors *nw*, *no*, and *nh* give the nitrogen required for wheat, oats, hay or pasture, respectively. For a given land type and conservation practice, a single production activity is set up for hay and pasture. This production can either be transferred to pasture (column 17) or baled for hay (column 16).

The second set of columns in the matrix in table 1 represent two steps on a stepped demand function for soybeans. These steps are

$$(2) \qquad P_1^s \text{ if } 0 \leq Q^s \leq Q_1^s \text{ and}$$
$$P_2^s \text{ if } Q_1^s \leq Q^s \leq Q_2^s,$$

where P_i^s is price of soybeans for the ith step, Q_i^s is maximum total quantity of the soybeans that will be purchased at the ith and higher prices with $P_1^s > P_2^s$. Each of these activities draws from the soybean production, as is indicated by the -1 coefficient in row 5. The soybean demand step constraints (rows 22 and 23) reflect the inequality shown in equation (2) above. For simplicity, only two steps are indicated in the matrix in table 1; the model contains seventy-five such steps.

The fourth, fifth, and sixth set of columns in the matrix in table 1 together represent steps on a demand function for corn and, for each respective corn-nitrogen fertilizer price ratio, represent steps on a fertilizer response function for corn; that is, the model calculates the optimal fertilization rate and associated yield for each market price.

Before considering this matrix formulation, consider the special class of response functions for which it applies. This class, used by Illinois agronomists to tailor fertilizer recommendations to individual situations (Illinois Cooperative Extension Service), is one for which the optimal per acre nitrogen fertilization rate is given by multiplying the maximum yield obtainable (for a given level of nonfertilizer management) times a factor that varies with the price ratio but not with the basic soil productivity level. The figures used as a basis for this study are given in column 2, table 2. These optimal nitrogen factors imply points on a response function. The points, expressed on the basis of percentage of maximum yield, are shown in column 4, table 2. The phosphorous and potassium fertilizer application rates are assumed to be equal to the amounts of these nutrients removed in the grain. This should approximately maintain the P and K levels in the soil (Illinois Cooperative Extension Service).

The steps on the demand function considered here are

$$(3) \qquad P_1^c \text{ if } 0 \leq Q^c \leq Q_1^c \text{ and}$$
$$P_2^c \text{ if } Q_1^c \leq Q^c \leq Q_2^c,$$

where P_i^c is price of corn for the ith step and Q_i^c is maximum total quantity of corn that will be purchased at the ith and higher prices with $P_1^c > P_2^c$.

To follow through the logic of the matrix formulation for incorporating the above type of response function and stepped demand functions into the model, first suppose that the supply price is P_1^c and thus that it is profitable to produce some amount of the product. With a positive price of nitrogen (V_n^c), the maximum per acre corn yield, given by the vector Y^c in the production activities set, will not be obtained if the optimal nitrogen rate is applied. Rather, at a price ratio of P_1^c/V_n^c, only $Y_1\%$ (from table 2) of the maximum per acre yield will be obtained. This is reflected in the model by the first sell corn activity, taking for each unit sold an amount $(100/Y_1)$ of the maximum per acre yield (row 2). To reflect the stepped nature of the demand function, the amount of the product that can be sold at P_1^c is constrained by the corn demand step row to be less than or equal to Q_1^c. The optimal nitrogen level is at a price ratio of P_1^c/V_n^c in n_1 pounds per unit of the product (from column 3, table 2). The total nitrogen requirement will thus be n_1 times the quantity sold at P_1^c. The cell of the matrix given by the corn nitrogen needs row (row 16) and the first sell corn column (column 14) will thus give the total quantity of nitrogen required.

Table 1. A Matrix Representation of the Model

Row Description	Crop Production Activities (acres)	Sell Soybeans (bu.)	Sell Corn (bu.)	Corn Production Correction Activity for Step 2	Correct Corn Harvest Costs	Correct Corn *P*, *K*, and Labor Requirements	Transfer *n* from Soybeans to Corn (lbs.)	Transfer *n* from Hay-Pasture to Corn (lbs.)	Buy *n* for Corn (lbs.)	Buy *n* for Wheat (lbs.)	Buy *n* for Oats (lbs.)	Buy *n* for Hay-Pasture (lbs.)	Buy Labor	Buy *P*	Buy *K*	Bale Hay (tons)	Pasture	Constraint
Objective function	$-C$	P_1^s P_2^s	P_1^c P_2^c	0	HC				$-V_n^c$	$-V_n^w$	$-V_n^o$	$-V_n^h$	$-V_l$	$-V_p$	$-V_k$	$-C$		max
Base corn production 1 (sell)	Y^c		$-\frac{100}{Y_1}$ $-\frac{100}{Y_2}$	$-\left[\frac{100}{Y_2}-\frac{100}{Y_1}\right]$														≥ 0
Base corn production 2 (correct harvest costs)	Y^c		-1 -1		-1													$= 0$
Base corn production 3 (*P*, *K*, and labor correction)	Y^c		-1 -1			-1												$= 0$
Soybean production	Y^s	-1 -1																≥ 0
Wheat production	Y^w																	$\geq WD$
Oats production	Y^o																	$\geq OD$
Hay-pasture account	Y^h															-1	-1	≥ 0
Hay production																1		$\geq HP$
Pasture production																	*aum*	$\geq PP$
Land	1																	$\leq L$
Terraceable land	1 or 0																	$\leq LAT$
Labor	L					$-l_c$							-1			L		≤ 0
Potassium fertilizer	K					$-p_c$								-1				≤ 0
Phosphorous fertilizer	P					$-k_c$									-1			≤ 0
Corn nitrogen needs			n_1 n_2	$(n_2 - n_1)$			-1	-1	-1									≤ 0
n supplied by soybean to corn	nsc						-1											≥ 0
n supplied by hay to corn	nhc							-1										≥ 0
Wheat *n* needs	nw									-1								≤ 0
Oats *n* needs	no										-1							≤ 0
Hay-pasture *n* needs	nh											-1						≤ 0
Soybean demand step 1		1																$\leq Q_1^s$
Soybean demand step 2		1																$\leq Q_2^s - Q_1^s$
Corn demand step 1			1															$\leq Q_1^c$
Corn demand step 2			1															$\leq Q_2^c - Q_1^c$
Corn transfer 2			1	$-(Q_2 - Q_1)/Q_1$														$= 0$

Table 2. Economically Optimal Nitrogen Rates for Corn

Corn Price Divided by Nitrogen Price	Optimal n Factor (lbs. n per bu. of maximum yield)	Optimal Pounds of n per Bushel of Actual Yield (n_i)[a]	Implied Yield as a Percentage of the Maximum Yield (Y_i)
∞	1.3382	1.3382	100.00
40	1.2931	1.2937	99.95
30	1.2780	1.2792	99.91
25	1.2659	1.2677	99.86
20	1.2479	1.2507	99.78
15	1.2178	1.2226	99.61
10	1.1575	1.1680	99.10
5	0.9766	1.0132	96.39
2	0.4341	0.5608	77.40
0	0	0	50.49

[a] The index increases as one goes down the column of figures.

Supposing that the maximum quantity that can be sold at P_1^f (Q_1^f) is sold, consider selling an additional quantity at the next highest price (P_2^f). Since P_2^f should be used in calculating the optimal nitrogen rate on the intramarginal production as well as the marginal production, the per acre yield and nitrogen rate used in producing the quantity sold at P_1^f must be adjusted if any production is sold at P_2^f. In the model this adjustment is affected by the addition of a correction activity (column 6) that must enter the basis if the second sell corn activity enters. Suppose now that P_2^f enters the solution at its limit of $(Q_2^f - Q_1^f)$. The constraint on row 26 will force the correction activity given by column 6 to enter the solution at a level of Q_1^f. This activity does not incur any direct cost; however, it does reduce the amount of the maximum production that can be sold by $Q_1^f[(100/Y_2) - (100/Y_1)]$. Also, it corrects the optimal amount of nitrogen by an amount equal to $Q_1^f(n_2 - n_1)$. If both P_1^f and P_2^f are at their limits, only Y_2% of the maximum possible production will be sold. This production will require n_2 pounds of nitrogen per unit of corn.

If P_1^f enters the solution at its limit, and P_2^f enters at a level less than its limit, the model will give a linear interpolation for yield between Y_1 and Y_2 and a linear interpolation for the nitrogen level between n_1 and n_2 pounds per unit of the product.

There are seventy-eight additional steps on the corn demand function that are not shown in table 1. These additional steps function in the same way as the second step.[3]

Since some harvest costs are proportional to yield, a correct corn harvest cost activity (column 7) is inserted into the model to reduce harvest costs by an amount equal to the per bushel harvest costs (HC) times the difference in the maximum production and the actual production. Similarly, column 8 in table 1 corrects labor requirements that are proportional to yield as well as the phosphorous and potassium fertilization rates for the difference in the maximum production and the actual production.

Additional activities are included in the model to: (*a*) subtract from corn nitrogen needs the amount of nitrogen added by legumes in rotation with corn; (*b*) purchase the required amount of inorganic nitrogen fertilizer for the crops; (*c*) purchase labor; (*d*) purchase phosphorous; (*e*) purchase potassium; and (*f*) allow hay to be baled at a cost of $C per ton or to substitute for pasture with the baling cost.

[3] An alternative way of putting response functions into a model of this type is to define a number of subactivities for different fertilization rates (see Taylor 1975b and Onishi). Then the model could choose a linear combination of the various rates as well as a linear combination of other characteristics of the production activities. The disadvantage of this formulation is that it substantially increases the size of the model, while the advantage is that one is not restricted to using a single response function for a crop nor restricted to the special type of function illustrated in table 2. To include subactivities for different fertilization rates in the model reported here, have the same degree of accuracy, and include rates that would be optimal for the same range of price variation would require eighty production subactivities (since there are eighty price levels and eighty steps on the response function) for each activity that has corn in the crop rotation. This would increase the number of columns in the model from 14,821 to 846,357 and decrease the number of rows by two (rows 3 and 4 and columns 6, 7, 8, and 9 would not be needed because these changes could be accounted for directly in the coefficients of the production activities). Consider the relative cost of solving the two formulations. The model in table 1 was solved on an IBM 360-75 computer using an IBM-MPSX package linked to a budget generator, which took thirteen minutes to generate the coefficients on tape in the format required by MPSX and twelve minutes to convert this data to a problem file, which is the internal working file for MPSX. To optimize from scratch takes thirty-five minutes of slow core (500K). The total cost was about $300 per run. Small revisions and the use of an old basis as a starting point in solving the model were less costly. Since the time required to generate the data and convert it to a problem file is, for this problem, about proportional to the number of columns, the model with the eighty subactivities would require 1,427 minutes for these two solution steps rather than twenty-five minutes. The time required to optimize this model would be more than thirty-five minutes, but how much more cannot be calculated a priori. Obviously, the model with eighty subactivities would be prohibitively expensive. Perhaps a less expensive computational strategy would be to cut down on the range of rates and, if the solution was at an extreme, generate new data and resolve until an extreme was no longer encountered.

The basic set of crop budgets used for the study was obtained by updating the prices and input levels in 1970 budgets that were prepared by Worden et al. for the USDA. Since a different regional delineation was used, budgets for LRA's were obtained by weighting with crop acreages the budgets for the USDA regions. These updated budgets for each crop and LRA were then modified to reflect the different yield levels of LCU's, tillage methods, conservation practices, and rotations. Yield adjustment coefficients for LCU's were obtained from unpublished USDA data (USDA 1975). The budgets were also modified to reflect nonyield cost differences for the alternative tillage methods, conservation practices, and rotations. These latter cost adjustment factors were obtained from many sources, including farm management manuals, experiment station bulletins, and unpublished data, but the primary source was the Illinois Cooperative Extension Service. All coefficients are for 1974 technology and price relationships. Specific coefficients will be furnished upon request.

The land acreage base for the model was obtained from the 1967 *National Conservation Needs Inventory* (USDA 1970). The land constraint in the model for a LCU within a LRA was the total of 1967 acreage devoted to the six crops, idle land, and land in conservation programs. The soil loss coefficients in the model were based on the universal soil loss equation (Wischmeier and Smith). The equation is

$$A = RK(LS)CP, \tag{4}$$

where R is rainfall and erosivity index, K is soil-erodibility factor, LS is a topographic factor that represents the combined effects of slope, length, and steepness, C is a cover and management factor, and P is a factor for conservation practices. Values for these factors were obtained from Lee, Wischmeier and Smith, and USDA (1975). For continuous corn under a spring plow system, A ranges from about 3 tons to over 340 tons. Fall plowing increases these figures by an average of about 10%, while chisel plowing reduces them by about one-half. Erosion under straight row cultivation is over 5 times higher than erosion on a terraced field.

Model Results

To provide a base from which to measure the effects of a policy, the model was solved without any pollution policy imposed. This solution, henceforth called the benchmark solution, is summarized in the first column, table 3. The remainder of this table gives the model results for the policies evaluated in this study. These results are discussed in the next five sections. A comparison of the benchmark acreages with actual 1969 acreages is made in table 4 for each LRA.

Herbicide Ban

The impact of herbicide ban on per acre crop yields was based on data from a six-year experiment in which yields with and without herbicides were compared (Slife). Without herbicides, corn yields were reduced by 19%, and soybean yields were reduced by 22%. In line with Slife's data, it was assumed that without herbicides two additional cultivations of corn and soybeans would be made.

As indicated in table 3, the ban reduced consumers' surplus by over $3.5 billion but increased producers' surplus (the economic rent to land) by about $1.8 billion. This policy also reduced the fertilizer load in the environment but increased by 13% the insecticide load in the environment. The insecticide load increased largely because of changes in the location of corn production. Labor used in crop production increased by 7%, largely because of the additional cultivations of corn and soybeans.

Insecticide Ban

Estimates of the effects of per acre crop yields of banning all insecticides are shown in table 5 for each land resource area. For crops and crop rotations not shown in this table, the yield effects are zero. The figures given in table 5 were based on personal communication with entomologists familiar with the Corn Belt (Kogan, Kuhlman) and the corn rootworm study by Taylor (1975a). These estimates apply to the short run. It is not clear what the long-run effects of banning all insecticides would be. On one hand, the elimination of insecticide pressure might permit the insect infestations to increase over the levels experienced in the near past. But on the other hand, the continued use of insecticides might result in an insect population that is resistant to the insecticides and perhaps even more damaging than current strains of insects.

Table 3. Estimated Effects of the Policies

Effect	Policy																		
	Bench-mark	Her-bicide Ban	Insec-ticide Ban	Nitro-gen Re-stric-tion (100 lbs./ acre)	Nitro-gen Re-stric-tion (50 lbs./ acre)	No Straight Row Culti-vation	$SL \leq 2$	$SL \leq 3$	$SL \leq 4$	$SL \leq 5$	$5/acre	$10/acre	$15/acre	$20/acre	$40/acre	$4.0/T	$2.0/T	$1.0/T	$0.5/T
Change in consumers' surplus ($ million)	0	−3,536	−632	−321	−3,325	12	−1,206	−1,007	−729	−433	0.3	0	−27	−27	−27	344	252	286	161
Change in producers' surplus ($ million)	0	1,799	531	21	2,036	−145	15	527	480	232	0.1	38	194	333	942	−1,506	−959	−722	−458
Government cost ($ million) excluding administrative costs	0	0	0	0	0	0	0	0	0	0	6	150	381	578	1,233	−772	−515	−328	−212
Crop prices: corn ($/bu.)	2.46	3.04	2.60	2.56	3.08	2.46	2.80	2.62	2.54	2.52	2.46	2.46	2.46	2.46	2.46	2.44	2.44	2.44	2.46
Soybeans ($/bu.)	5.26	6.58	5.22	5.24	5.82	5.28	6.26	5.76	5.58	5.44	5.26	5.26	5.28	5.28	5.28	5.56	5.44	5.34	5.30
Wheat ($/bu.)	4.97	5.42	5.01	4.87	5.34	4.97	3.45	4.51	5.04	4.93	4.97	4.97	4.99	4.99	4.99	4.57	4.74	4.79	4.82
Oats ($/bu.)	2.33	2.58	2.38	2.30	2.67	2.33	1.45	2.40	2.39	2.40	2.33	2.33	2.34	2.34	2.34	2.19	2.28	2.26	2.28
Hay ($/ton)	56.15	62.53	57.75	56.07	63.73	55.97	55.33	58.07	58.36	57.13	56.14	56.05	56.21	56.21	56.19	51.01	52.67	53.21	54.15
Production: corn (mil. bu.)	3,744	3,286	3,637	3,658	3,266	3,744	3,484	362	3,683	3,698	3,744	3,744	3,744	3,744	3,739	3,750	3,760	3,751	3,744
Soybeans (mil. bu.)	785	607	791	790	714	785	655	72	743	767	785	785	785	785	785	746	763	777	782
Acres terraced (mil.)	0	0	0	0	0	0	23.63	9.19	2.18	2.04	1.19	15.02	25.43	28.92	30.83	18.53	7.74	1.25	1.02
Conservation tillage (mil.)	77.33	77.33	77.33	79.72	78.87	77.34	77.97	79.06	76.24	77.34	77.33	77.40	77.41	77.41	77.47	81.20	79.82	78.27	78.21
Gross soil loss (mil. tons from planted acreage)	596	589	595	586	592	337	155	243	304	323	594	522	475	453	438	193	258	328	424
Gross soil loss (tons/acre planted)	5.33	5.28	5.33	5.24	5.29	3.01	1.21	2.07	2.74	2.88	5.26	4.12	3.46	3.21	3.07	1.49	2.16	2.90	3.75
Insecticide expenditures index	100	113	0	95	111	100	89	103	93	93	100	100	102	102	101	92	93	94	94
Herbicide expenditures index	100	0	101	101	102	99	89	93	97	100	100	100	99	99	99	100	99	101	100
N load (bil lbs.) on corn acreage*	4.19	3.81	3.57	3.19	2.20	4.19	3.99	4.10	4.15	4.16	4.19	4.19	4.19	4.19	4.19	4.20	4.20	4.20	4.19
Average *N* load (lbs./acre) on corn acreage	100.58	85.89	85.22	75.83	48.73	100.69	102.13	101.19	100.71	100.52	100.58	100.57	100.84	100.84	100.81	99.64	99.88	100.00	100.24

* Total of nitrogen from organic and inorganic sources.

Table 4. Planted Acreages of Crops 1969 Actual and Benchmark Solution

Region	Corn and Grain Sorghum		Small Grains		Soybeans		Hay and Pasture	
	Actual	Model	Actual	Model	Actual	Model	Actual	Model
	1,000 acres							
Wisconsin and Minnesota sandy outwash	218	0	153	487	7	0	608	781
Southeastern Wisconsin drift plain	1,677	789	781	1,810	191	789	1,981	1,930
Southwestern Michigan fruit and truck belt	109	95	46	223	16	0	106	136
Southern Michigan drift plain	1,428	2,844	610	523	607	645	1,184	1,225
Loess, till, and sandy prairies	5,259	5,718	3,689	2,611	1,151	2,039	3,803	4,145
Central Iowa and Minnesota till prairies	4,976	4,993	1,132	1,460	3,644	4,308	2,084	2,276
Eastern Iowa and Minnesota till prairies	1,630	1,356	465	415	789	1,356	984	1,021
Northern Mississippi Valley loess hills	1,440	1,980	660	22	133	0	2,511	2,644
Nebraska and Kansas loess-drift hills	1,474	1,028	418	382	280	748	1,013	1,112
Iowa and Missouri deep loess hills	3,189	2,001	530	328	1,406	2,001	2,205	2,613
Illinois and Iowa deep loess and drift	7,874	8,241	1,218	247	4,090	4,619	3,096	3,328
Iowa and Missouri heavy till plain	1,207	890	253	0	897	611	2,927	3,270
Northern Illinois and Indiana heavy till plain	1,472	1,541	203	56	1,135	1,541	291	395
Indiana and Ohio till plain	4,480	4,591	1,687	4,283	3,475	2,272	2,434	2,329
Central claypan areas	870	1,421	384	302	983	657	956	907
Southern Illinois and Indiana thin loess and till plain	1,729	2,035	563	0	1,420	2,035	1,236	1,364
Central Mississippi Valley wooded slopes	2,015	2,249	627	339	1,269	1,238	2,506	2,340
All	41,047	41,700	13,419	13,488	21,493	24,859	29,925	31,816

For the insecticide ban, consumers' surplus decreased by $632 million, while producers' surplus increased by $531 million. The price of corn increased by 14¢, but the price of soybeans declined by 4¢. The soybean price drop or the production increase resulted from growing more corn in rotation with soybeans to avoid large insect losses to corn.

Nitrogen Restriction

For the nitrogen policy, it was assumed that the per acre rate would be reduced from a mean rate of about 140 pounds (including nitrogen added in manure and by legumes) to a maximum of either 50 or 100 pounds. It was further assumed that a restriction would apply to any source of nitrates including those added by legumes. Since the precise relationship between nitrogen fertilizer applications and nitrate pollution damages has not been established (Aldrich), there is presently no sound basis for restricting fertilizer use to either level. The 50 and 100 pound levels were chosen to cover the range of possible restrictions.

Table 5. Estimated Average Yield Change from Banning all Insecticides

Region	Rotation			
	Corn after Corn	Corn after Soybeans	Corn after Small Grains	Corn after Hay or Pasture
	%			
Wisconsin and Minnesota sand outwash; southeastern Wisconsin drift plain	−10	0	−4	−8
Southwestern Michigan fruit and truck belt; southern Michigan drift plain	−8	0	−5	−5
Loess, till, and sandy prairies; central Iowa and Minnesota till prairies, eastern Iowa and Minnesota till prairies; northern Mississippi Valley loess hills	−15	−2	−5	−10
Nebraska and Kansas loess-drift hills	−8	0	−3	−8
Iowa and Missouri deep loess hills	−10	0	−5	−8
Illinois and Iowa deep loess and drift	−15	−2	−5	−10
Iowa and Missouri heavy till plain	−12	−2	−5	−10
Northern Illinois and Indiana heavy till plain	−8	0	−2	−6
Indiana and Ohio till plain	−5	0	−2	−6
Central claypan areas; southern Illinois and Indiana thin loess and till plain; Central Mississippi Valley wooded slopes	−2	0	−2	−5

The 100 pound restriction reduced consumers' surplus by $231 million, while the 50 pound restriction reduced it by $3,325 million. Producers' surplus increased by $21 million with the 100 pound restriction and by $2,036 million with the lower restriction. Producers' surplus increased with the restriction primarily because the price and quantity changes to a large extent occurred in the inelastic portion of the demand curve for corn and soybeans. Thus, a nitrogen fertilizer restriction, which would clearly be to the disadvantage of an individual landowner if imposed only on his farm, would be to his advantage if imposed in a large region.

Under the 50 pound restriction, corn acreage increased by 3.5 million acres. But the higher acreage did not compensate for the reduction in per acre yield. Hence, the quantity produced went down by 478 million bushels, and price went up by 62¢ per bushel. Although the restriction gave soybeans a comparative advantage over corn, the increased pressure on the land base for corn production increased the price of soybeans by 56¢ per bushel. The restriction reduced the acreage of corn grown in rotation with soybeans or small grains; hence, insecticide expenditures increased by 11¢.

The average nitrogen load on corn acreage decreased from a benchmark level of 101 pounds per acre to 76 pounds per acre under the 100 pound restriction and to 49 pounds per acre under the 50 pound restriction. The load is below the restriction level because the optimal nitrogen rate on some of the poorer land is below the restriction level and the average is pulled down. The nitrogen load was reported in terms of corn acreage because the other crops do not require substantial addition of nitrogen to the soil. Unfortunately, the impact of this reduced load on the nitrate content of water supplies is an unclear issue at the present time and may continue to be so in the near future because of the complexity of the nitrogen cycle (Aldrich). Until this information becomes available, it will not be possible to compute the social value of damages abated by nitrogen restrictions.

The administrative and enforcement costs associated with a per acre restriction would indeed be very high. Strict enforcement would obviously be unworkable because it would require a twenty-four hour check on all fields. Perhaps an acceptable degree of compliance could be achieved with very stiff penalties for violators combined with random on-the-spot checks. Other nitrogen policies that have lower enforcement costs, such as taxes and markets for pollution rights, have been suggested for this problem (Taylor 1975b); however, these policies would not be expected to be as effective in controlling the intensity of use as a restriction. If the intensity of use, as opposed to total use, is the major factor causing unacceptable nitrate levels in water, then the per acre restriction may be the best alternative. In fact, this was the only policy mentioned in the Illinois Pollution Control Board's proposed plant nutrient regulations.

Erosion Controls

The estimated effects of alternative erosion control policies are shown in table 3. Accepting Harberger's applied welfare economics postulate that producers' and consumers' surpluses should be added to arrive at the net social cost of an action, we find the relationships between gross soil loss and net social cost (excluding administrative costs and environmental values) that are shown in figure 1. As expected, the socially least costly method of achieving a specified level of soil loss is a tax. The terracing subsidies are substantially more costly than the other control methods considered; however, a terracing cost sharing policy rather than the policy that paid the same per acre amount (irrespective of actual costs of terraces) would have a lower social cost.

A per acre soil loss restriction is only slightly less efficient than the tax policy for reducing soil loss from 595 million tons to about 400 million tons. For achieving a soil loss level of about 337 million tons, a ban on straight row cultivation (i.e., require contouring or contouring and terracing) is only slightly more costly than a tax policy and less costly than a per acre restriction.

In table 3 there are substantial equity differences between the types of erosion control policies. Under the per acre restriction, landowners gain and consumers lose, while the opposite holds for a tax policy. To achieve a soil loss level of about 330 million tons costs $108 million with a tax, $201 million with a per acre restriction, and $133 million with a ban on straight row cultiva-

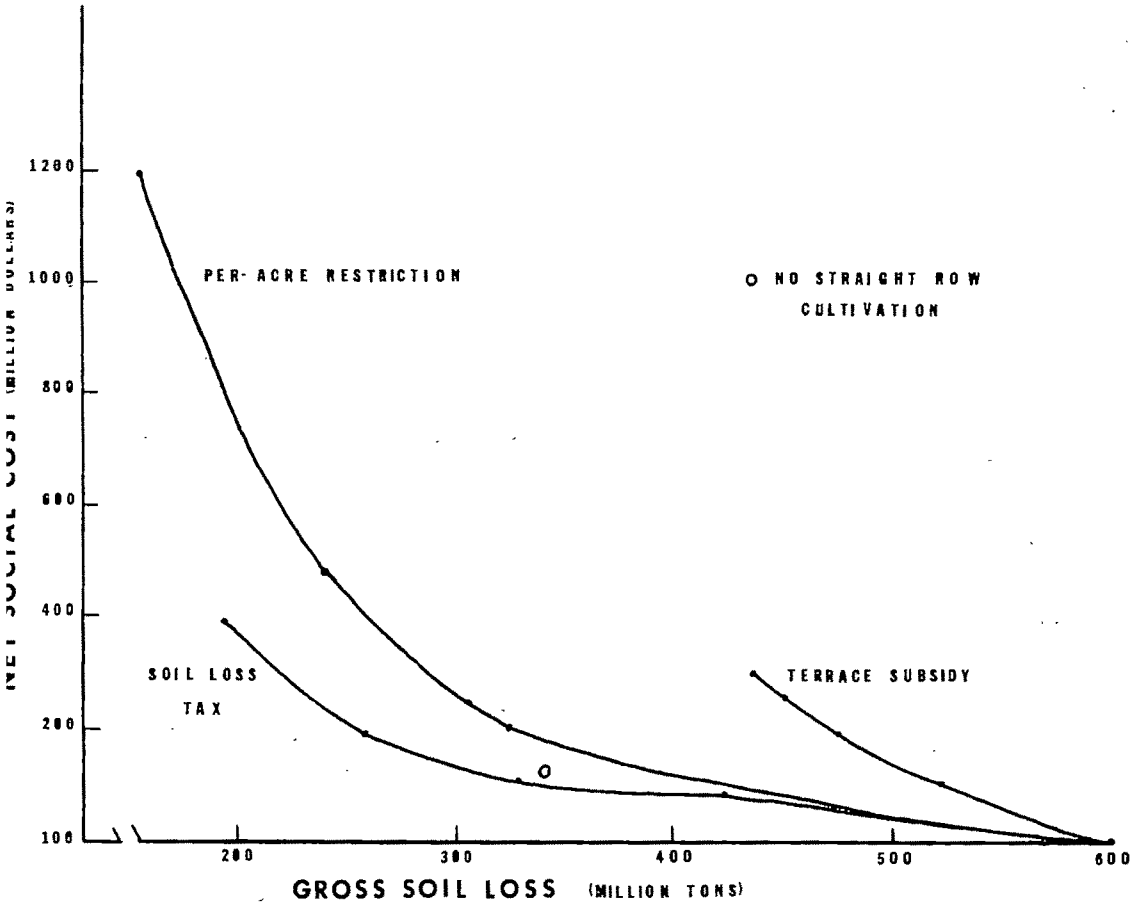


Figure 1. The relationship between net social cost and gross soil loss for the alternative erosion policies

ion. Landowners lose $722 million annually under a tax policy, gain $232 million under a per acre restriction, and lose $145 million with a ban on straight row cultivation. The direction of these land rent effects result primarily from the inelastic demand for corn and soybeans. To achieve a soil loss of 330 million tons, consumers lose $33 million under the per acre restriction, gain $12 million with the ban on straight row cultivation, and gain $286 million under the tax policy. The consumer gain results from the two policies primarily because of relatively lower values for hay and pasture.

Another equity aspect that policy makers might want to consider is the relative impact of the control methods on low income consumers. Because a terracing subsidy policy does not significantly affect prices, the major effect on consumers will be through increased income taxes. Given the progressive nature of the U.S. tax structure, this policy may affect low income consumers much less than a policy such as a per acre restriction, which significantly increases food prices but not taxes. The soil loss tax policy might benefit low income consumers the most because it would lower food prices as well as lowering taxes.

Concluding Remarks

A very large linear programming model of crop production in the Corn Belt was presented. This model incorporated stepped demand functions for corn and soybeans and therefore gives an approximate competitive equilibrium solution for these markets. One advantage of this model over other norma-

tive regional models of crop production (see, e.g., Taylor 1975b, Mayer and Hargrove, Heady et al.) that have been used to analyze pollution policies is that it gives a market equilibrium solution. The other models have either been formulated with constant prices or with the quantity demanded fixed. A second important advantage of the model presented here is that it gives a measure of the change in social welfare resulting from a policy, namely, the change in consumers' plus producers' surplus.

A third advantage of this model formulation is that it incorporates the determination of optimal fertilization rates for corn in a computationally more efficient way than has been done in other models. The increased computational efficiency of this formulation allows much more detail to be added either with respect to the number of fertilization rates allowed or with respect to other input levels.

This model was used to estimate the effects of various controls on nonpoint agricultural sources of pollution. Extreme controls of banning all herbicides, banning all insecticides, and limiting nitrogen fertilizer use were evaluated to illustrate the consequences that may result if the 1985 goal of zero pollution is strictly interpreted. These runs also show the importance of these chemical inputs to agriculture when price effects and regional shifts in production are accounted for.

Controls on gross soil erosion, which are more likely to be implemented than severe constraints on the use of most chemicals in agriculture, were also evaluated. As expected, a soil loss tax is the least costly method for achieving soil loss reductions. However, a per acre restriction, perhaps a politically more viable alternative, was found to be only slightly more costly than a tax for achieving up to a 50% reduction in erosion. The terrace subsidy policy considered was substantially less efficient than the other policies, but a policy that paid only the cost of the terraces rather than a flat rate might be much more efficient.

Future research on agricultural nonpoint sources of pollution needs to concentrate on estimating the external costs of pollution and the administrative and enforcement costs of pollution controls. After this information is obtained, a model of the type presented here could be modified to include these costs and give the socially optimal level of pollution. Future research should also concentrate on finding the optimal mix of point and nonpoint pollution.

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U.S. Agricultural Production Capacity

Chung J. Yeh, Luther G. Tweeten, and C. Leroy Quance

This study examines production capacity based on measures of farmers' and consumers' behavioral responses to alternative assumed prices. Impacts of inflation on capacity are also examined. A conceptual framework is outlined, analyzed, and applied to alternative scenarios of projected supply-demand conditions to 1985. Results indicated that long-range U.S. farm production capacity is unlikely to be challenged by 1985. Farmers have substantial capacity to respond to challenges posed by unfavorable weather or other disturbances at home and abroad. Because demands are expected to remain less than supply potential, unutilized supply capacity is expected to remain high.

Key words: capacity, demand, feasible, inflation, production, scenarios, supply, unutilized.

Interest in the production potential of U.S. agriculture is shared by nations around the world concerned about possible food shortages and by farmers and consumers in this nation concerned about prices of farm products. Estimates of production capacity can help such parties at home and abroad anticipate future conditions and make decisions before events reach crisis proportions.

A number of studies have addressed issues of production capacity (Brandow; Heady, Faber, and Sonka; USDA 1973). This study, unlike previous ones, examines production capacity based on measures of farmers' and consumers' behavioral responses to alternative assumed prices. The objectives are to present a conceptual framework for analyzing production capacity and to apply this conceptual framework to alternative scenarios of projected supply-demand conditions to 1985. We discuss results only for 1985, but data were generated for each year using the Economic Research Service's (ERS's) National-Interregional Agricultural Projections (NIRAP) System (Quance).

Chung J. Yeh and Leroy Quance are agricultural economists in the National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture, and Luther G. Tweeten is Regents Professor in the Department of Agricultural Economics, Oklahoma State University, Stillwater.

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Defining Production Capacity

In our market-oriented economy, agricultural output is determined by the price system and public policies underlying investment in agricultural research, extension, education, and resource development. Accordingly, production capacity is measured within the context of prices and public policies required to realize that capacity and is directly tied to the supply function relating output to price. Of course, weather also influences output, but this study focuses on those changes in output that arise from decisions of farmers and consumers.

Within a meaningful range of prices, additional output is not unattainable, only uneconomical. The concept of absolute maximum production capacity is rejected in this study in favor of a more operational concept of feasible supply capacity.[1] Feasible supply

[1] Preliminary calculations indicate that the United States has production potential to provide 3,000 calories of food per day for each of the 4 billion men, women, and children in the world. (Current world consumption averages approximately 2,400 calories per day.) Each pound of wheat, corn, or grain sorghum provides just over 2,000 calories; hence, the entire world requires 2.19 trillion pounds of grain or 39.1 billion bushels of corn-equivalent per year. Disregarding problems of spoilage and waste, the entire output requirement would be filled with corn-equivalent yields in the United States as follows: 77.4 bushel yield on 413 million acres comprised of 317 million cropland acres harvested in 1973 and 96 million acres of cropland with high conversion potential, plus 38.7 bushel yield on 57 million acres of potential cropland with medium conver-

capacity is that output at which the supply curve becomes very unresponsive to price because quality land, fertilizers, other conventional inputs, and management are at such limits that additional output comes only at substantial costs (figure 1); that is, huge quantities of resources would have to be diverted from nonfarm uses to farm uses to gain additional output. Feasible supply capacity must be defined somewhat arbitrarily and is determined in this study on the basis of resource availability, the slope of the supply curve, and the magnitude of prices received relative to prices paid by farmers.

Economic texts define excess supply as supply quantity minus demand quantity at any given price. Quance and Tweeten define excess capacity as the volume of farm production capacity diverted from the commercial market by government programs of acreage diversion, stock accumulation, and food aid. In this study, excess supply capacity is defined as projected supply quantity minus demand quantity at a given price.

Excess supply capacity can be divided into two components—demand reserve and supply reserve. If producer prices are held at the equilibrium P_e and consumer prices held at P_i, a quantity $Q_e - Q_d$ of reserves emerges called the demand reserve in figure 1. If consumer prices are held at P_e and producer prices raised to P_i, a quantity $Q_s - Q_e$ of reserves emerges called supply reserve because it arises from supply response. Together, the demand and supply reserves constitute excess supply capacity $Q_s - Q_d$.

Unutilized supply capacity is the difference between feasible supply capacity and quantity supplied at any price P_i, or $Q_f - Q_s$, while reserve capacity is the difference between feasible supply capacity and demand quantity at any given price P_i, or $Q_f - Q_d$, equal to excess supply capacity plus unutilized capacity in figure 1. Feasible supply capacity is achieved only at a very high price. Public and private measures to meet emerging food needs should be very different if the projected quantity demanded at some future date exceeded, rather than fell short of, feasible supply capacity.

Ability to cope with unanticipated shifts in demand and supply depends strongly on the magnitude of the buffer between quantity supplied and demanded at price P_i. If excess supply capacity is maintained consistent with P_i, then an increase in demand from the quantity Q_d to an unanticipated larger quantity Q_s because of unfavorable weather abroad or for other unforeseeable reasons can be met with the current year's reserve supply without an increase in price above P_i. Or, supply can shift unpredictably from the expected quantity Q_s to a lower actual quantity Q_d, and the shock can be absorbed without a price increase above P_i.

Excess supply capacity is a less ready reserve than commodity stocks.[2] Prices set initially at P_e must be raised to P_i to realize excess supply capacity $Q_s - Q_d$. The reserve is more readily available if price is maintained at P_i year after year. This approach, while maintaining a ready reserve, is very costly. Resources are committed at P_i that have higher value in other uses. These resources, or production therefrom, must be diverted from commercial markets either by paying farmers not to produce, by mandatory controls, by accumulating storage stocks, or by other means.

With a price increase from P_e to P_i, less excess supply capacity is generated in the short run than in the long run because consumers depress food purchases less and farmers increase output less. The long-run supply response, with price P_i maintained for a sustained period, is greater because time is

sion potential, plus 19.4 bushel yield on 112 million acres of potential cropland with low conversion potential, all potentials as classified by the Conservation Needs Inventory (Cotner, Skold, and Krause). While this output would not necessarily be the absolute maximum production capacity, some sacrifice would be required by Americans, including diversion of investment from other activities and direct consumption of cereal and vegetables without processing into meat through animals. Our standard of living would fall sharply as resources were diverted from current uses to massive irrigation programs, land clearing, fertilizer production, etc. Very troublesome issues emerge including transportation, storage, disincentives to food producers in other nations, inability of importers to provide payment, etc. Maximum feasible production capacity is unnecessary under conceivable circumstances and is included here only to illustrate one example of maximum production potential, a tangential concept for this paper.

[2] Agricultural production capacity can be conceptualized in ways different from that reported above. This study does not consider capacity in the very short run; thus, commodity storage stock options are not examined. Maximum production capacity as reported earlier is not considered. Changing the form of farm output constitutes another reserve to feed people. Livestock can be slaughtered to meet current food needs, which provides immediate nutrients from meat and frees crops to be used directly for human consumption at the expense of future meat consumption. Although shifting crop output from processing through livestock to direct human consumption has occurred in the past (e.g., margarine replacing butter) and is expected to continue, we foresee no sharp acceleration of this trend in the future. At high food prices, this trend would be speeded in ways not fully accounted for in this study.

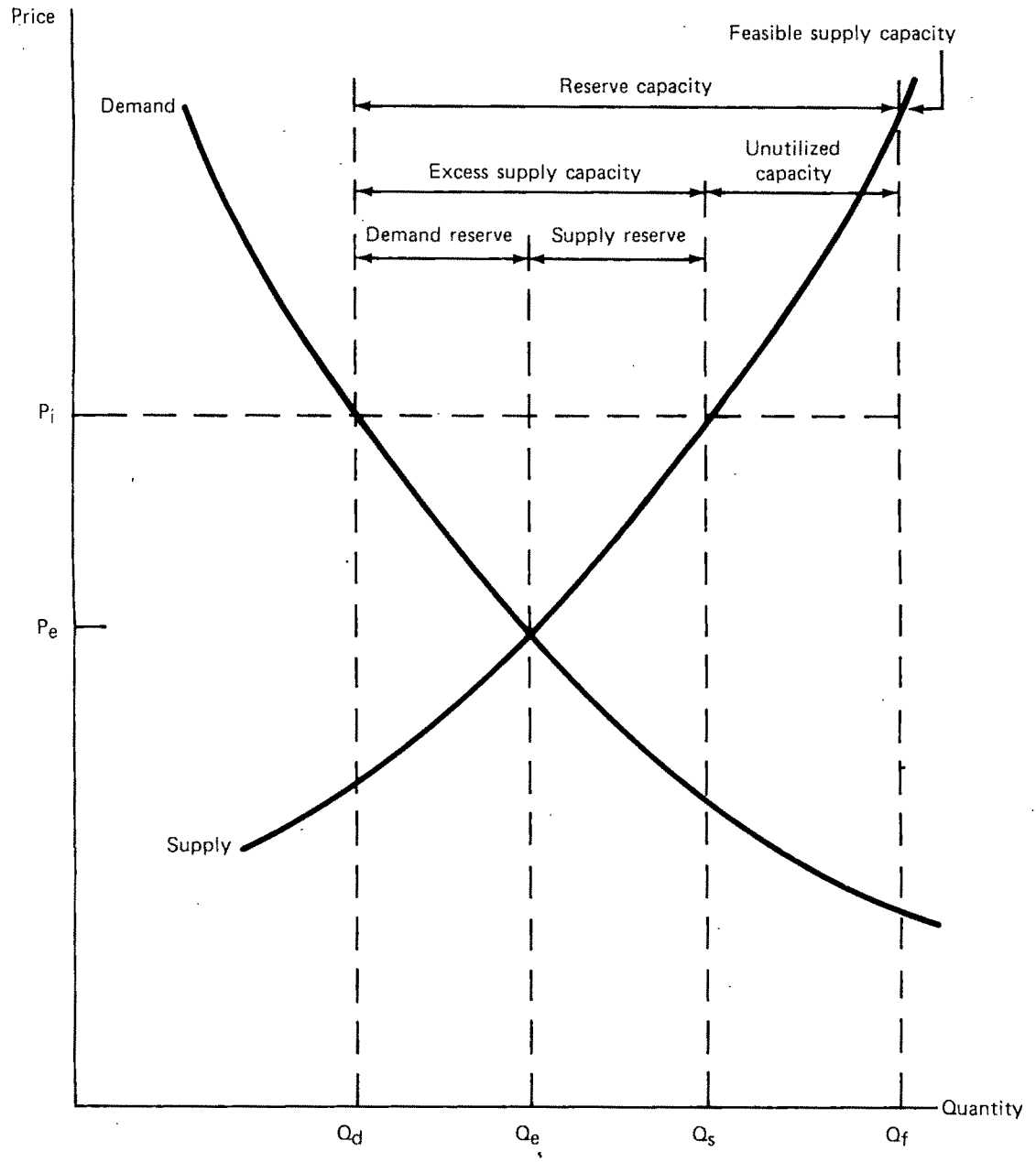


Figure 1. Supply and demand curves illustrating concepts of production capacity

required for farmers to become convinced that additional investment in plant and equipment is justified and for nonfarm firms to increase capacity for supplying production inputs purchased by farmers. The long-run demand response is greater because consumers take time to substitute foods that require fewer resources for foods that require more resources and in other ways adjust diets and substitute nonfood purchases for food purchases. We analyze only "long-run" excess supply capacity in this report, where "long run" is defined as the price P_i maintained from 1975 to 1985.

This study measures output capacity rather than the capacity to provide a number of persons with adequate diets. The capacity to provide more people with adequate diets as farm prices increase is underestimated by our projections, since people substitute foods that require fewer resources to provide an adequate diet (e.g., high lysine corn consumed

directly) for conventional foods if the real prices of food increase markedly.

Parameters and Scenarios

Supply is expressed with two principal parameters: short-run and long-run price elasticities. The NIRAP system performed well in predicting the 1967–74 period with aggregate supply elasticities of 0.2 in the short run (one to two years) and 1.0 in the long run (many years). These results are broadly consistent with past econometric estimates (Tweeten and Quance), adjusted for the increasing short-run elasticity caused by rising proportions of price-responsive inputs such as fertilizer and falling proportions of price-unresponsive inputs such as land and operator and family labor (Yeh).

Demand is also expressed with two principal parameters: short-run and long-run price elasticities. Based on previous econometric studies and the ability to predict historically the 1967–74 period, price elasticities of aggregate demand were selected to be −0.15 in the short run and −0.21 in the long run (Yeh).

Scenarios define the conditions under which supply, demand, and production capacity are projected to the year 1985. The scenarios depict a range of conditions judged most probable. However, the scenarios do not encompass transitory shocks such as intermittent grain purchases for export to the Soviet Union, annual variations in weather, commodity stock adjustments, and other factors that bear heavily on short-run conditions but not on long-run trends. Also, the scenarios do not take into account public policy actions that may be taken to counteract undesirable events, should they appear likely.

Critical scenario components are demand shifters (population, income, and exports) and supply shifters (productivity and inflation).

Supply Shifters

The productivity index is the ratio of aggregate output of the farm production sector to aggregate production inputs. It is assumed that an increase in productivity shifts the supply curve to the right and that additional agricultural research and extension (R&E) outlays raise the amount of farm output available from any given amount of farm production inputs (Cline, McNiel, and Lu).[3]

Alternative levels of R&E expenditures and resulting changes in productivity are considered. The first alternative denoted by T_3 assumes continuation of the observed rate of real growth in R&E during the 1939–72 period—3% per year, a baseline assumption. The second alternative denoted by T_{7+} assumes the continuation of the average rate of real growth in R&E during the 1944–50 period—7% per year—and also includes productivity gains from unprecedented technologies.[4] This is perhaps the upper limit on expected productivity growth through 1985. The estimated annual compounded increase in productivity from T_3 is 1.14%, denoted by $S_{1.14}$, and from T_{7+} is 1.21%, denoted by $S_{1.21}$, from 1975 to 1985 (Cline, McNiel, and Lu). Historical annual average increases in productivity averaged 2.33% in 1950–59, 0.92% in 1960–69, and 1.19% in 1963–72 (USDA 1975a). Although the annual productivity increase measured by the 1965–67 to 1973–75 average was 0.87%, a third alternative, a zero growth rate from 1975 to 1985 denoted by S_0, is considered in the study. Many people believe this may happen or even that there will be a negative productivity growth before 1985.

Other practices such as minimum tillage are not explicitly included in this study but offer potential for greater output from a given dollar volume of production resources (USDA 1975c). Weather also influences the long-run expected productivity trend to the extent that its cycles influence domestic farm production. No provision for these cycles is made in productivity projections herein. Omitting weather conditions is not to deny existence of weather cycles but rather to recognize that these cannot yet be predicted with sufficient reliability to include, in a causal way, in long-run supply projections. Furthermore, this study does not estimate

[3] Effects of increasing R&E are not immediately apparent but are spread over many years. Most occur within thirteen years with the peak effect approximately six years after the year in which extension and research funds are spent (Cline, McNiel, and Lu).

[4] Unprecedented technologies include breakthroughs that are likely to occur at specific times as judged by agricultural scientists but are not included in conventional productivity indices. The three unprecedented technologies are twinning in beef cattle, bioregulators, and photosynthesis enhancement. However, only bioregulators can influence productivity by 1985. Emerging unprecedented technologies are most widely used with greater R&E outlays: hence, their impact is only included with annual real increments on R&E outlays of 7%.

new outlays for public programs to clear, drain, or irrigate additional land but allows for completion of projects authorized and funded.

Inflation as measured by the GNP implicit price deflator has increased historically at a rate similar to that of prices paid by farmers, including interest, taxes, and wage rates. From 1960 to 1969, both indices increased by 24%. From 1972 to 1974, however, prices paid by farmers increased 32%, while general prices increased 18%. The more rapid increase in prices paid by farmers is in part attributed to high energy and fertilizer prices, which carry a larger weight in farm prices than in general prices, and by the interfarm sales component of prices paid by farmers, which increase in price commensurate with the rapid gain in prices received by farmers for crops and livestock. In the future, the rate of gain in prices paid by farmers is expected to return to the historical pattern in relation to the rate of national inflation.

In the empirical analysis, two alternative inflation rates are examined: I_4, the baseline standard case of 4% annual inflation; and I_8, an 8% annual inflation rate in prices paid by farmers. The latter rate is considerably higher than that prior to the 1970s but lower than those farmers experienced in the 1970s.

Inflation shifts the supply to the left at the rate $-BI$, where B is the elasticity of supply and I is the inflation rate of an annual percentage increase in prices paid by farmers for production items including interest, taxes, and wage rates. The vertical axis in figure 1 is illustrated in real rather than in the customary nominal prices. Hence, the impact of inflation on the supply curve is not readily apparent but is included in the analysis. Documentation of the aggregate farm output model of the NIRAP system gives detailed accounts of the impact (Yeh). Influences of inflation in prices paid on prices received by farmers in the empirical analysis are in conformity with the theory outlined elsewhere (Tweeten).

Demand Shifters

U.S. population growth rates are series II and III projections from the Bureau of the Census (U.S. Dep. Commerce). With the population increasing by 0.85% annually from 1970–74 and by 0.70% in 1974 and in the light of falling birth rates, series III projections with an annual growth rate averaging 0.68% (table 1) from 1975–85 were selected as the baseline. Series II projections with annual population growth averaging 0.92% were also included because trends in birth rates can not be accurately anticipated, as evident by past projections.

Table 1. Projected Annual Percentage Increases in Farm Output Demand, 1975–85

Export Growth Rate	Domestic Population Growth	
	II (0.92)[a]	III (0.68)
	High Income[b]	
	(3.2)	(3.3)
3.5	1.73	1.55
4.4	1.88	1.70
6.0	2.15	1.97
	Medium Income	
	(2.5)	(2.7)
3.5	1.66	1.47
4.4	1.81	1.63
6.0	2.08	1.90
	Low Income	
	(1.9)	(2.0)
3.5	1.58	1.40
4.4	1.73	1.55
6.0	2.00	1.82

[a] Roman numerals refer to Bureau of the Census population series, with annual percentage rates in parentheses.
[b] Annual percentage growth in per capita income shown in parentheses below.

The agricultural export growth has been highly volatile in the past and is hazardous to predict. Two rates of future annual agricultural export growth, 3.5% and 4.4% (table 1), were projected by the Foreign Demand and Competition Division (USDA 1976a).

The projections of 3.5% to 4.4% annual growth from 1975 to 1985 appear reasonable in light of present knowledge, but exports could increase at a faster rate, having increased by an average 6% per year from 1967–74, with a large portion of the increase occuring in 1973. While gains of the 1973 magnitude are rare, a faster growth rate alternative of 6% for 1975–85 accounts for any possible continuation of the 1967–74 experience.[5]

[5] These export projections do not measure the need for U.S. farm products abroad.Rather, the estimates reflect projected effective demand for U.S. farm products abroad, which depends, among other things, on ability to pay for U.S. farm

Projected increases in per capita disposable income were computed from working data supplied by Resources for the Future (USDA 1976b). Their annual rates ranging from 3.3% to 2.7% for 1975–85 under population series III appear too high in light of the 2.4% annual gain from 1967–74 and the decline in real income from mid-1973 to mid-1975. Furthermore, higher energy prices may restrain economic growth for an extended period. Consequently, a lower growth rate in income, 2.0%, was included as a third alternative. Comparable high, medium, and low annual rates of growth in real income for population series II were, respectively, 3.2%, 2.5%, and 1.9%. The income elasticity of demand for food and fiber output at the farm level was considered to be 0.14 for 1975–85. Income growth estimates are unique to each population series because income and population interact—lower per capita gains in income are associated with high population growth. However, total national product is greater with higher rates of population growth because population increments are not entirely offset by per capita income loss.

The eighteen possible combinations of the demand shifters (table 1) are too numerous to simulate separately, and only two overall rates of growth in demand are considered. Several combinations of export, income, and population alternatives project the same shift in total demand for farm output. The very highest rates of growth in income seem unlikely to occur. Excluding the highest growth rates in income for 1975–85, the highest annual rate of growth in demand is 2.1% (a combination of an export growth of 6.0%, a population growth of 0.92%, and an income growth of 2.5%). This rate and a standard case or baseline estimate of 1.5% (conforming with the baseline export growth of 3.5%, population growth of 0.68%, and per capita real disposable personal income growth of 2.7%) constitute the two alternatives simulated and are designated as $D_{1.5}$ and $D_{2.1}$. As shown in table 1, these shifts are consistent with several combinations of demand shift components.

Summary of Scenarios

Five scenarios combining different rates of growth in the supply and demand for farm output are analyzed, including a baseline containing the most likely levels of growth to 1985 in supply and demand and four alternatives permitting a limited analysis of the impact on production capacity and especially on reserve capacity of different expected growth rates in technology, inflation, and demand through 1985. In summary, the scenarios are as follows.

(*a*) Baseline ($D_{1.5}\,S_{1.14}\,I_4$)—continue the observed 1939–72 rate of real growth in R&E of 3% per year; 4% annual inflation in prices paid by farmers for nonfarm produced production inputs, including interest, taxes, and wage rates; and a 1.5% annual growth in demand for farm output resulting from various combinations of moderate annual growth in farm exports and in domestic population and income.

(*b*) High technology ($D_{1.5}\,S_{1.21}\,I_4$)—the same supply and demand assumptions as under the baseline except that a higher than expected annual growth in real R&E expenditures—the 7% per year that occurred during the 1944–50 period—and the productivity gains from the unprecedented technologies are included.

(*c*) High inflation ($D_{1.5}\,S_{1.14}\,I_8$)—the same supply and demand assumptions as under the baseline except that a higher than expected annual growth in input price inflation, 8%, is assumed.

(*d*) High demand ($D_{2.1}\,S_{1.14}\,I_4$)—the same supply and demand assumptions as under the baseline except that a higher than expected annual growth in demand for farm output, 2.1%, is assumed, possibly resulting from a combination of higher than expected growth rates in domestic population and income and/or exports.

(*e*) Low technology ($D_{1.5}\,S_0\,I_4$)—the same supply and demand assumptions as under the baseline except that a lower than expected annual shift in supply is included—the 0% per year from 1972 to 1985.

Results

The basic analysis is conducted at the national level with respect to aggregate farm output. The aggregate farm output component of the NIRAP system was used for this purpose (Yeh). In this component, demand is expressed as a function of nominal price and supply as a function of real prices reflecting

products out of funds gained from international exports and aid credits.

the impact of inflation on supply responses. In the simulation, the prices received are determined and expressed as the nominal price. However, in presenting results consistent with the theory outlined earlier, real prices (price ratio) are obtained by deflating externally the prices received by prices paid by farmers for production items, including interest, taxes, and wage rates.

The NIRAP system also includes commodity supply-demand and regional farm commodity production, crop yield, and land-use detail (Quance). However, only illustrative projections relating to commodity production and land use are summarized here.

Equilibrium outcomes show prices and output under various scenarios if prices and quantities are established by market forces at the intersection of supply and demand in the absence of production controls. No excess supply capacity exists at equilibrium, but the entire unutilized supply exists. The equilibrium results in table 2 (first line for each alternative) show estimated output and unutilized supply if the farming economy follows an unconstrained adjustment path to 1985. Alternatively, real prices (ratio of prices received by farmers for crops and livestock to prices paid by farmers for production items, including interest, taxes, and wage rates) are raised to the indicated levels of 120, 140, and 180 from 1975 to 1985.

In the absence of inflation in prices paid by farmers, the price ratio increases steadily from 106 (1967 = 100) in 1974 to 110 in 1985 as demand increases 1.5% annually, while supply increases 1.14% annually due to technology. Under the baseline scenario, the above gain in prices received is more than

Table 2. Agricultural Output and Reserve Capacity under Alternative Scenarios and Price Ratios, 1985

Scenario and Price Ratio[a]	Prices Received	Output[b]	Reserve Capacity (%)[c]			
			Excess Supply			
			Demand Reserve	Supply Reserve	Total	Unutilized Supply
Baseline						
101	264	114.0	0	0	0	67.5
120	322	131.5	3.6	13.3	16.9	45.2
140	393	152.2	6.0	25.1	31.1	25.4
180	540	190.9	8.4	40.3	48.7	0
High technology						
99	259	114.3	0	0	0	68.5
120	325	132.8	3.9	13.9	17.8	45.0
140	395	153.6	6.3	25.6	31.9	25.4
180	539	192.6	8.5	40.7	49.2	0
High inflation						
92	357	107.1	0	0	0	78.2
120	486	131.5	5.0	18.6	23.6	45.2
140	592	152.2	7.1	29.6	36.7	25.4
180	810	190.9	8.9	43.9	52.8	0
High demand						
108	287	119.8	0	0	0	59.3
120	324	131.5	2.3	8.9	11.2	45.2
140	394	152.2	4.1	25.4	25.4	25.4
180	539	190.9	8.0	37.2	45.2	0
Low technology						
112	299	111.4	0	0	0	54.6[d]
120	324	118.9	1.5	6.3	7.8	44.8
140	393	137.1	4.6	18.7	23.3	25.6
180	541	172.2	7.7	35.3	43.0	0

[a] Price ratio is the index of prices received by farmers for crops and livestock divided by index of prices paid by farmers for production items, including interest, taxes, and wage rates. The preliminary 1974 value is 106 (1967 = 100).

[b] Preliminary actual value of output in 1974 is 108 (1967 = 100). Output here includes interfarm sales and cannot be compared directly with published output series.

[c] Both excess and unutilized supply are expressed as a percentage of output quantity (1967 = 100) at price ratio P_t.

[d] If feasible supply is believed to be 190.9, then the corresponding unutilized supply capacity will be 71.4, 60.6, 39.2, and 0 for the price ratio of 112, 120, 140, and 180.

offset by the 4% annual inflation in prices paid by farmers, and the price ratio falls slightly from 106 in 1974 to 101 in 1985 (table 2). However, the index of prices received increases from 184 (actual) in 1974 to 264 in 1985. One of the reasons that the real price levels at equilibrium decline under most of the scenarios is that demand is considerably less elastic than the supply——0.15 in the short run and −0.21 in the long run for demand and 0.2 in the short run and 1.0 in the long run for supply. Under such conditions, a 1.5% annual shift in demand is not enough to offset the price impact of a 1.14% annual shift in supply from technology.

Feasible supply capacity is judged to be in full use at a real price ratio of 180 under all scenarios. Under the baseline and high inflation scenarios, the feasible supply capacity output is 190.9% of the 1967 output and increases slightly to 192.6% under the high technology scenario. Feasible supply capacity output is 76.9 (190.9 − 114.0) index points (1967 = 100) above equilibrium output under the baseline, hence unutilized capacity is 67.5% of equilibrium output. This implies that by sustaining the price ratio at 180 from 1975 to 1985, output could be two-thirds larger than the equilibrium quantity demanded and supplied.

Quantity demanded would fall from 114.0% of the 1967 output at equilibrium in 1985 to 97.9% if a price ratio of 180 was sustained from 1975 to 1985.[6] Thus, with a price ratio of 180, the 1985 demand reserve (see figure 1) expressed as a percentage of output would be 100(114.0 − 97.9)/190.9 or 8.4%. The 1985 supply reserve is 100(190.9 − 114.0)/190.9 or 40.3%. Thus, of the 93.0, that is, (190.9 − 97.9), index points of excess supply at the feasible supply capacity with a price ratio of 180, 17.2% is demand reserve and 82.8% is supply reserve, the latter dominating due to supply being considerably more responsive than demand to price, especially as length of run is expanded.

A more rapid positive shift in the supply curve due to greater public R&E expenditures does not significantly affect either output or reserve capacity by 1985 as indicated by comparing the high technology case to the baseline. Although the high technology case is a low cost source of agricultural output as indicated by high rates of return on investment, the output and capacity impact is small because of the long lag between expenditures on research and resulting gains in output.

By 1985, high R&E expenditures will lead to equilibrium output 114.3% of 1967 output, with an unutilized reserve capacity sufficient to increase output by 68.5%, slightly more than under the baseline. Feasible supply capacity increases more than equilibrium output because the greater output associated with high R&E outlays results in a lower price ratio to farmers, which restrains conventional input use.

The negative supply shifter, inflation, has a major impact on equilibrium prices and output, a significant impact on reserve capacity, but no impact on feasible supply capacity. With annual increases in prices paid by farmers of 8%, the 1985 farm output is only 107% of 1967 output, compared to 114% under the baseline assumption of 4% annual inflation. The unfavorable economic incentives to produce caused by a low ratio of prices received to prices paid restrain actual output but do not affect potential output as measured by feasible supply capacity. Thus, reserve capacity is very large with high inflation because equilibrium output is low. Massive increases in prices received by farmers are required to realize feasible supply capacity with high inflation rates. For example, by 1985 a price ratio of 180 with an 8% inflation rate will imply an index of prices received by farmers that is 810% of the 1967 average.

Whether demand expansion is rapid or slow does not influence feasible supply capacity, but it does influence the capacity actually utilized. High demand generates favorable price ratios for farmers, causing output to increase. By 1985, equilibrium output will be 119.8% of 1967 output with demand increasing 2.1% per year. Consequently, both excess supply and unutilized capacity are greater for slow than for rapid gains in demand.

The output and capacity is smaller under the 0% shift in the supply than under the baseline. By 1985, equilibrium output will be 111.4% of the 1967 output, and feasible supply capacity will drop as much as 23% from the baseline.

[6] Although the quantity demanded at above equilibrium price ratios is not shown in table 2, it can be calculated as follows. At a price ratio of 180 under the baseline scenario, excess supply is 48.7% of output and thus quantity demanded is 51.3%. The demand quantity at price ratio 180 is (0.513) (190.0) = 97.9.

The excess supply capacity estimates in this study are annual flows in the long run for prices above equilibrium. With expected outcomes under these prices, farmers again pile up huge reserves unless resources are diverted from production. It is well to keep in mind that time, as well as favorable prices, is required to reach the nonequilibrium, high output levels depicted in table 2.

Commodity Estimates

Using commodity supply-demand components of the NIRAP system, we have generated selected commodity estimates consistent with the aggregate farm output production capacity projections summarized above. Opportunities to substitute commodities in both production and consumption make any commodity disaggregation somewhat arbitrary. Our commodity capacity estimates depend on supply and demand parameters that have performed well in a range of projected equilibrium conditions. Because supply estimates are of greatest interest, only capacity estimates that depend on supply are shown for individual commodities. In setting the aggregate price ratio above equilibrium levels, we assume that the component domestic and export demands increase in equal proportions. The resulting supply capacity quantities and prices are feasible points on commodity supply curves. As with aggregate farm output, supply reserve capacity is zero at equilibrium and greatest at the 180 price ratio where unutilized supply is zero.

The real (1974 dollars) supply price for corn drops below the 1974 corn price in the 1985 equilibrium solution. Prices received by farmers relative to prices paid would have to rise above 120 (1967 = 100) before the corn supply price increases above the 1974 corn price of $2.95 per bushel. According to these baseline estimates, if the 1974 real price of corn was maintained until 1985, corn producers would be willing to supply annually approximately 42% more corn than in 1974 and 9% more than the projected equilibrium demand quantity in 1985.

Equilibrium prices in 1985 for other commodities summarized in table 3 are above 1974 prices. Real prices increase about 47% for beef, veal, and wheat and 10% for soybeans from 1974 to 1985. Market-clearing quantities for 1985 are 2% above 1974 levels for beef and veal, 24% for wheat, and about 30% for corn and soybeans.

The feasible supply capacity for 1985 is projected to be corn, 9.6 billion bushels; wheat, 3.5 billion bushels; soybeans, 2.6 billion bushels; and beef and veal, 38.2 billion pounds. Comparable 1985 capacity projections from the 1973 ERS capacity study are corn, 9.1 billion bushels; wheat, 2.3 billion bushels; soybeans, 2.3 billion bushels; and beef and veal, 35.3 billion pounds (USDA 1973).

The 1973 study made the following general assumptions: (*a*) farm product prices favorable for increased production, (*b*) no restrictions on land use, (*c*) adequate input supplies at relatively favorable prices, and (*d*) normal growing conditions. The current study maintains these general assumptions but utilizes the supply and demand components of the NIRAP system to make the price relationships explicit and to apply the conceptual framework outlined earlier in defining and projecting individual demand reserve, supply reserve, and unutilized supply components of production capacity. Given conceptual differences, the 1973 capacity estimates are reasonably consistent with those in this study except for wheat. According to projections generated in this report and considering the 1974 wheat crop of 1.8 billion bushels and the 1975 crop of 2.14 billion bushels, the 1973 wheat capacity projection to 1985 appears to be conservative.[7]

Land and Fertilizer Supplies

Crop yield and land use estimates for the selected commodities at the national level are summarized in table 3. Relative prices well above estimated equilibrium levels bring into production marginal land with lower yield potential, tending to lower national average crop yields. But higher relative prices also encourage irrigation development, greater use of fertilizer, improved machinery, and other types of yield-increasing management practices.

The cropland base is 472 million acres with

[7] Some of the additional acres planted to wheat would come from grazing lands. Higher commodity prices induce clearing, brush and weed control, fertilization, and other measures to raise grazing output. Furthermore, additional cropland needed even at high product prices is small relative to the 900 million acres of grazing lands. Thus, output of grazing lands is expected to increase with higher price ratios.

Table 3. Selected Results under the Baseline Scenario with Alternative Prices, 1985

Commodity and Price[a]	Price Ratio[b] (1967 = 100)	Million Acres Harvested[c]	Output[d] Quantity (mil.)	Output[d] Percentage of 1974	Supply Reserve[d] (mil.)	Unutilized Supply Capacity[d] (mil.)
Corn						
2.95 (1974)	106	61.9[e]	4,651	100	—	—
2.52 (equil.)	101	54.4	6,056	130	0	3,546
2.98	120	59.5	6,617	142	561	2,985
3.58	140	72.6	8,076	174	2,020	1,526
4.94 (feas. cap.)	180	86.3	9,602	206	3,546	0
Wheat						
4.04 (1974)	106	53.9[e]	1,793	100	—	—
5.91 (equil.)	101	57.4	2,222	124	0	1,301
6.97	120	62.7	2,428	135	206	1,095
8.38	140	76.6	2,963	165	741	560
11.54 (feas. cap.)	180	91.0	3,523	196	1,301	0
Soybeans						
6.69 (1974)	106	55.8[e]	1,233	100	—	—
7.39 (equil.)	101	50.8	1,621	131	0	949
8.72	120	55.5	1,771	144	150	799
10.48	140	67.8	2,161	175	540	409
14.44 (feas. cap.)	180	80.6	2,570	208	949	0
Beef and veal						
36.00 (1974)	106	—	23,500	100	—	—
53.00 (equil.)	101	—	24,100	102	0	14,100
62.00	120	—	26,300	112	2,200	11,900
75.00	140	—	32,100	137	8,000	6,100
103.00 (feas. cap.)	180	—	38,200	163	14,100	0

[a] Prices are in "real" 1974 dollars per bushel for grain and dollars per hundredweight for beef and veal.
[b] Price ratio is the prices received relative to prices paid by farmers.
[c] The actual yields (bu./acre) in 1973 were 91.2 for corn, 31.7 for wheat, and 27.7 for soybeans. The projected yields (bu./acre) in 1985 for all price levels are 111.3 for corn, 38.7 for wheat, and 31.9 for soybeans.
[d] Quantities are in million bushels for grains and million pounds for beef.
[e] The 1973 actual figures.

about 107 million acres being in cropland pasture and soil improvement uses (table 4). These latter acres are considered unavailable for actual crop production in computing future cropland needs. A recent estimate indicates that there are about 265 million acres of land not classified as cropland but with cropland potential (Cotner, Skold, and Krause). This land has various kinds and degrees of limitations that influence the high to low conversion potential indicated in table 4.

The equilibrium 1985 aggregate farm output could be produced without additional land conversion, and the aggregate price ratio for 1975–85 could increase above 120% of 1967 before any of the conversion potential is needed. At a price ratio of 140 and an output 52% greater than 1967, 54% of the acreage with high conversion potential would be used. At the feasible supply capacity price ratio of 180, 100% of the 95.7 million acres of high conversion potential could be used plus 48% of 27.4 million acres of the medium potential acreage. Much of the high and medium potential land would be available in the short run (one to two years), but a high proportion of this land is grassland in the Plains states that could be used only for wheat and low-yielding feed grains. About 55 million acres of the high and medium potential land requires development, mainly drainage. Public as well as private land development investments, along with overcoming environmental problems, is required. No capacity situation projected in this study requires converting any of the 112 million acres with low potential for conversion to cropland.

Pinstrup-Andersen gives some clues to supply of phosphate and potash. World potash reserves are currently estimated to be 79 billion tons of K_2O of which 10 billion tons are readily available. This compares with world production of 22 million tons of K_2O

Table 4. Land Use and Conversion Potential of Land, Baseline Scenario, under Specific Prices[a]

Land Use and Conversion Potential	1973	1985 Ratio of Prices Received to Prices Paid 101	120	140	180
Aggregate farm output (1967 = 100)	104.8	114.0	131.5	152.2	190.9
Cropland used for crops (mil. acres)					
Cropland harvested	317	286	313	382	453
Summer fallow and idle[b]	36	35	35	35	35
Cropland pasture and soil improvement[b]	107	107	107	107	107
Total	460	428	455	524	595
Available cropland (mil. acres)	472	472	472	472	472
Additional cropland needed (mil. acres)	—	—	—	52	123
Conversion potential required for supply capacity (%)					
High	0	0	0	54	100
Medium	0	0	0	0	48
Low	0	0	0	0	0
Total	0	0	0	20	47

[a] Cropland availability and cropland conversion potential estimates were provided by the Natural Resource Economic Division, ERS (see Cotner, Skold, and Krause; USDA 1975b).
[b] Some of this land has potential use for crops, but in these calculations none was considered available.
[c] Acres of land not classified as "available cropland" are estimated to have conversion potential as follows: 95.7 million, high; 57.0 million, medium; and 111.8 million, low, for a total of 264.5 million acres.

in 1973–74. World phosphate rock reserves are estimated to total 76.1 billion tons, and 16 billion tons are estimated to be recoverable at current costs. He estimated 150 years of available consumption at current real costs. Nitrogen is available from the air, but current processing requires hydrocarbons derived from sources such as natural gas, petroleum, or coal. Although natural gas and petroleum supplies could run short, coal stocks are available for hundreds of years at current consumption rates. The drop in prices of nitrogen and phosphate fertilizers in 1976 as a result of large supplies generated by earlier high prices in 1973–74 suggests greater quantities can be generated by higher prices. Given time and adequate prices, the fertilizer industries seem capable of responding to demands to 1985. In the case of imported phosphate and potash, troublesome issues could emerge regarding availability of supplies in the face of possible international political exigencies.

Conclusions

A set of agricultural projections depict alternative futures based on the conceptual framework outlined here and scenarios differing with respect to levels of major influences on the supply and demand for food and fiber. The results can help anticipate emerging needs and required actions before events reach crisis proportions.

Under a projected supply-demand baseline scenario to 1985, including a 1.5% annual increase in demand, a 1.14% annual increase in supply from technology, and 4% annual input price inflation, the U.S. farm sector could have a feasible supply capacity approximately double the 1967 output and 67% larger than the projected 1985 equilibrium output. Feasible supply capacity (at a ratio of prices received by farmers to prices paid by farmers 80% greater than the 1967 ratio) for selected commodities in 1985 are corn, 9.6 billion bushels; wheat, 3.5 billion bushels; soybeans, 2.6 billion bushels; and beef and veal, 38.2 billion pounds. The feasible supply capacity could require that all of the 95.7 million acres of noncropland with high potential for conversion to cropland and 48% (27.4 million acres) of the medium potential noncropland be used in production, which would require major investments.

Long-range U.S. farm production capacity is unlikely to be challenged by 1985. Farmers have substantial capacity to respond to challenges posed by unfavorable weather or other disturbances at home and abroad. Whether actual output is relatively large or small depends on demands placed on the farming

industry in the future. Because such demands are expected to remain less than supply potential, unutilized supply capacity is expected to remain high in the future.

Farmers have much less ability to respond to needs of more output in the short run than in the long run. For example, maintaining an excess supply capacity in 1985 to fill in that one year shortages of the relative magnitude that occurred in 1973 would require a price ratio maintained at nearly 120% of the 1967 average from 1975 to 1985.

Changes in relative prices and use of conventional resources will have a greater impact on farm output in the next several years than will changes in technology through public research and extension. These latter activities require considerable lag time for their efforts to be felt and have comparatively small impact on farm output because they comprise a small part of all agricultural resources.

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Toward an Aggregative Measure of Saving and Capital Finance for U.S. Farm Operator Families

John B. Penson, Jr.

The present economic accounting system for the farm production sector fails to measure the personal saving of sector participants and its allocation between financing farm and nonfarm investments. This paper discusses the conceptualization, estimation, and usefulness of two economic accounts covering 1970–75 that provide this information for farm operator families, the largest group of sector participants. These accounts also identify the portion of annual farm capital accumulation financed by internal versus external funds. Analytical ratios illustrating the substantial amounts of equity capital withdrawn to finance nonfarm investments in recent years are presented.

Key words: capital accumulation, capital finance, personal gross saving, portfolio balance.

A fully integrated system of economic accounts should provide a comprehensive and detailed framework for the systematic recording of stocks and flows. The adequacy of such an accounting system should then be judged by whether it can accurately and completely portray the operation and performance of an economic system and the welfare of its participants. In the past, the system of economic accounts for the U.S. farm production sector has consisted primarily of the income account published in *Farm Income Statistics* and the balance sheet account published in the *Balance Sheet for the Farming Sector* (USDA 1976b, c). The strengths and weaknesses of these accounts should be well known to the readers of this *Journal*. Carlin and Handy, for example, recently reviewed the scope and design of these accounts and the role they play in the present sector economic accounting system. Simunek recently estimated a farm capital flow account that, if added to the present sector economic accounting system, would identify specific sources of change in stocks of farm production capital between successive balance sheets.

John B. Penson, Jr., is an assistant professor in the Department of Agricultural Economics, Texas A&M University.

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Yet the sector economic accounting system continues to lack an account or set of accounts that would provide analysts with information on the gross saving of farm production sector participants and the extent to which they finance their farm and nonfarm investments with internal versus external sources of funds. Without this information, analyses of the changing financial position of farm production sector participants must be viewed as partial and incomplete.

Several accounts designed to fill this information gap have recently been proposed in this *Journal* and elsewhere. Much of the attention has centered around the sources-and-uses-of-funds statement for the farm production sector maintained by the Federal Reserve Board and the alternative sources-and-uses-of-funds statement proposed by Penson, Lins, and Irwin. The latter account sought to broaden the scope and design of the Federal Reserve Board account by including, among other things, revaluations of farm real estate as an internal flow of capital. Unfortunately, Penson, Lins, and Irwin failed to separate those real estate capital flows requiring finance from those that do not such as own-account formation of real estate improvements and land revaluations. Brake and Barry recommended further disaggregation of this account, and the exclusion of those transactions that do not de-

scribe the receipt or expenditure of cash. Melichar proposed a procedure for identifying the uses of funds to purchase farm real estate from discontinuing proprietors. Finally, Simunek estimated a farm capital finance account that, among other things, demonstrated the application of saving by farm production sector participants to finance purchases of farm production capital. Yet each of these flow-of-funds accounts represents only a partial answer to the information gap identified above. None of the previously proposed accounts have provided an overall measure of the annual personal consumption and gross saving by farm production sector participants. The scope of the accounts estimated by Melichar and by Simunek was limited to farm capital finance while the accounts estimated by Penson, Lins, and Irwin and by Brake and Barry did not identify nonfarm investments of farm production sector participants apart from their personal consumption outlays. In addition, the sources and uses of funds of farm operator families in each of these accounts were comingled with those of nonoperator landlords and other farm production sector participants, making it impossible to discern whether farm operator families as a group exhibit consumption, investment, and borrowing behavior different from that of other groups.

The purpose of this paper is to review the concepts behind and discuss the estimation and usefulness of two economic accounts that together would allow analysts to observe the manner in which selected groups of farm production sector participants use their personal gross savings to finance farm and nonfarm investments. The scope of the estimated accounts is limited to a coverage of farm operator families, the largest group of farm production sector participants.[1] Their personal consumption and gross saving are measured in a personal income and outlay account. In addition, their finance of farm real estate purchases and capital accumulated on farms is measured along with their net additions to equity in nonfarm capital via a capital finance account. An attempt is made to allow for the effect on gross saving and capital finance of withdrawals by those farm operator families leaving the farm production sector. Procedures to complete these accounts with presently available data are emphasized. Since specific assumptions and statistical procedures are required for the completion of the accounts, data inadequacies are discussed as they arise.

Personal Income and Outlay Account

Carlin and Handy present a conceptual overview of the scope and design of a sector personal income and outlay account. As they suggest, the usefulness of this account can be enhanced by disaggregating sector participants into selected target groups. For the farm production sector, a set of personal income and outlay accounts should be developed for such groups of sector participants as farm operator families, nonoperator landlords, hired labor families, and nonfarm investors such as limited partners.

One of the more important features of this set of disaggregated personal income and outlay accounts is that they would provide an estimate of the personal gross saving by each group of sector participants. Personal gross saving is determined residually in the account by subtracting personal consumption and personal tax and nontax payments from total personal income. Total personal income for each group of sector participants is determined by adding their wages and salaries, rental income, interest and dividends, social security payments, and other income transfers received to the operating surplus of farm and nonfarm businesses accruing to those sector participants having a proprietary interest. For farm operator families (the target group focused on in this study), total personal income is comprised of their net cash farm income and net additions to farm inventories plus any income received from off-farm employment, nonfarm investments, and government. Their personal outlays consist of purchases of nondurable goods and services, personal tax and nontax payments, and personal gross saving.

Those readers interested more in a discussion of the usefulness of the personal income and outlay account for farm operator families presented in table 1 than the statistical procedures and assumptions necessary to

[1] Farm operator families are chosen as the target group for study in this paper because of their relative number and data availability. Little or no information is available at present to estimate the consumption, gross saving, and nonfarm investments of the remaining target groups.

Table 1. Personal Income and Outlay Account, Farm Operator Families, Current Dollars, 1970–75

Item	1970	1971	1972	1973	1974	1975
	Billion $					
Personal income						
1. Current farm operating surplus of farm operators[a]	16.7	17.5	21.4	36.3	30.3	30.3
2. Off-farm wages and salaries, royalties, dividends and interest, nonfarm business profits and professional income, and social security benefits	17.4	18.8	20.5	23.7	26.4	28.4
Total	34.1	36.3	41.9	60.0	56.7	58.7
Personal outlays						
3. Personal tax and nontax payments	3.0	3.2	3.4	4.4	5.1	5.1
4. Net flow of disposable income withdrawn by discontinuing farm operator families	0.5	0.6	0.6	0.5	0.3	0.5
5. Repair and operation of household capital items	3.0	3.1	3.1	3.3	4.3	4.5
6. Purchases of nondurable goods and services by continuing farm operator families[b]	14.8	15.6	16.7	18.2	22.6	26.0
7. Personal gross saving by continuing farm operator families	12.8	13.8	18.1	33.6	24.4	22.6
Total	34.1	36.3	41.9	60.0	56.7	58.7

[a] Net cash farm income plus net additions to farm inventories of continuing farm operator families.
[b] Includes food, household operations, cash rent of living quarters, household dwelling insurance, other housing expenses, clothing, medical care, automobile insurance, personal care, personal insurance, cash gifts and contributions, education, tobacco and alcoholic beverages, recreation, and miscellaneous expenses. Expenditures for shelter, household furnishings and equipment, and motor vehicles are included instead in the capital finance account.

complete the account may skip the following section. These procedures and assumptions are presented to facilitate reestimation of selected entries for those who favor alternative procedures or assumptions and to underscore the nature of the data and need for more frequent surveys pertaining to these entries.

Estimation of the Account

While each of the entries in the personal income and outlay account presented in table 1 is based upon published data, some are estimated from statistical procedures given by the synthesis of data from several different sources. Several assumptions as to the applicability of the results from special surveys to years not covered by the sample are required. Still other entries reported on a net basis require the consolidation of several data series. The following equations and the variable description given in table 2 document the statistical procedures and sources of data used:

$$(1)\quad FOS_{foft} = GCFY_t + \Delta I_{foft} - GCFOE_t - NR_{nopt} - NFY_{ct},$$

$$(2)\quad OFY_{foft} = ((OFY/N)_{foft})(N_{foft}),$$

$$(3)\quad PY_{foft} = FOS_{foft} + OFY_{foft},$$

$$(4)\quad DPYW_t = \Phi(\Delta N_{foft})(PY_{foft}/N_{foft}),$$

$$(5)\quad PCON_{foft} = r_{oi}\left(\sum_{i=1}^{3} 0.33(PY_{foft-i} - PTAX_{t-i} - DPYW_{t-i})\right),$$

and

$$(6)\quad PGS_{foft} = PY_{foft} - PTAX_t - DPYW_t - ROHCI_t - PCON_{foft}.$$

Personal income of farm operator families from farm production activities shown on line 1 of the account is estimated from equation (1). Line 2 of the account, which reports the income earned by farm operator families from off-farm sources, is given by equation (2). Together, equations (1) and (2) account for the current total personal income of these sector participants.[2]

The personal tax and nontax payments entry (line 3) is published in *Farm Income Statistics*, while repairs and operation of

[2] Net additions to crop and livestock inventories on farms are assumed to be accumulated solely by continuing farm operator families since share rents owed to nonoperator landlords have already been deducted and nonoperator landlord purchases of livestock amounted to less than 2% of total livestock purchases in 1970 according to survey estimates presented by Penson and Williams.

Table 2. Variable Description and Sources of Data

Variable	Variable Description and Data Source
FOS_{foft}	Current farm operating surplus accruing to farm operator families (equation (1))
$GCFY_t$	Current cash receipts from farm marketings, other farm income, and government payments (USDA 1976c, pp. 44–45) minus internal sales of breeding livestock (Penson and Williams)
ΔI_{foft}	Current net additions to crop and livestock inventories (USDA 1976c, p. 45)
$GCFOE_t$	Current gross cash farm operating expenses (USDA 1976c, pp. 48–49) minus breeding livestock purchases (Penson and Williams)
NR_{nopt}	Current net rent to nonoperator landlords including government payments (USDA 1976c, p. 54)
NFY_{ct}	Current corporate net farm income (Melichar, Sayre, and Holderness, table 710.2)
OFY_{foft}	Current off-farm income per farm operator family (equation (2))
$(OFY/N)_{foft}$	Current average off-farm income per farm operator family (USDA 1976c, p. 62)
N_{foft}	Current number of farms (USDA 1976c, p. 38)
$DPYW_t$	Current personal disposable income withdrawn by discontinuing farm operator families (equation (4))
Φ	-1 if ΔN_{foft} is < 0; 0 otherwise
$PCON_{foft}$	Current purchases of selected nondurable goods and services by continuing farm operator families (equation (5))
r_{ot}	Ratio of personal outlays for selected nondurable goods and services in 1973 (USDA 1975a) to expected total personal income of continuing farm operator families (equations (1) and (2)), or 0.54
$PTAX_t$	Current personal tax and nontax payments (USDA 1976c, p. 40)
PGS_{foft}	Current personal gross saving by continuing farm operator families (equation (6))
$ROHCI_t$	Current repair and operation of household dwellings (USDA 1976c, p. 51) and motor vehicles where the latter is given by one minus the fraction allocated to business expenses (USDA 1969, p. 11), or 0.78 and 0.40, times the repair and operation of trucks and autos (USDA 1976c, p. 51) divided by the fraction allocated to business expenses
$PGSFC_{foft}$	Current personal gross saving of continuing farm operator families used to finance farm capital accumulation (equation (7))
$TFCA_{foft}$	Total current farm capital accumulation by continuing farm operator families (equation (14))
CB_{foft}	Current total capital borrowing by continuing farm operator families (equation (8))
APP_{foft}	Current total principal payments on debt outstanding by continuing farm operator families (equation (8))
$REDO_t$	Current year-end farm real estate debt (USDA 1976b, p. 19)
$RFCE_{foft}$	Current retained farm earnings of individual and family-held farm corporation; given by NFY_{ct} minus profits tax accruals and dividends paid (Melichar, Sayre, and Holderness, table 730.3) multiplied by the fraction of total gross corporate farm sales accounted for by individual and family-held farm corporations (Coffman), or 0.71
$TVET_t$	Current value of voluntary and estate real estate transfers (USDA 1976d, p. 24)
r_{nopro}	Fraction of total real estate loan funds borrowed by nonoperator landlords in 1970 (Penson and Williams), or 0.09
r_{do}	Debt outstanding on real estate transferred as a fraction of $TVET_t$ in 1967 (USDA 1968, p. 23), or 0.15
$NREDO_t$	Current year-end non-real estate debt excluding CCC nonrecourse loans (USDA 1976b, p. 17)
r_{nopnd}	Fraction of total non-real estate loan funds borrowed by nonoperator landlords in 1970 (Penson and Williams), or 0.02
$TPMV_{foft}$	Current purchases of machinery and motor vehicles for business and household use minus trade-in value (equation (9))
$BPTK_t$	Current purchases of trucks for business use (USDA 1976c, p. 52)
r_{btk}	Fraction of total purchases of trucks allocated to farm business use (USDA 1969, p. 10), or 0.78
$BPAO_t$	Current purchases of autos for business use (USDA 1976c, p. 52)
r_{bao}	Fraction of total purchases of autos allocated to farm business use (USDA 1969, p. 10), or 0.40
$BPTE_t$	Current purchases of tractors and equipment (USDA 1976c, p. 52)
r_{nopc}	Fraction of total purchases of tractors and equipment bought by nonoperator landlords in 1970 (Penson and Williams), or 0.05
$PRECI_{foft}$	Current purchases of real estate capital improvements by continuing farm operator families (equation (10))
$PRECI_t$	Current purchases of real estate improvements (USDA 1976c, p. 52)
r_{nopr}	Fraction of purchases of real estate improvements by nonoperator landlords (Penson and Williams), or 0.09
$NPRE_{foft}$	Current purchases of farm real estate minus sales by continuing farm operator families (equation (11))
r_{baft}	Current fraction of the value of real estate transfers purchased by continuing farm operator families (USDA 1975b, p. 24)
r_{saft}	Current fraction of real estate sellers who are active farm operators at the time of the sale (USDA 1975b, p. 25)
r_{afr}	Fraction of farm operator families selling real estate who remained active in farming after the sale in 1964 (USDA 1965, p. 31), or 0.25
ΔHHF_{foft}	Current net additions to household furnishings and equipment by continuing farm operator families (equation (12))

Table 2. (Continued)

Variable	Variable Description and Data Source
$(HHF/P)_t$	Current year-end stock of household furnishings and equipment expressed in constant dollars (USDA 1976b, p. 5)
PP_{hft}	Current index of annual average prices paid for household furnishings and equipment (USDA 1976a, p. 460)
ΔCDD_{foft}	Current net additions to currency and demand deposits by continuing farm operator families (equation (13))
CDD_t	Current year-end stock of currency and demand deposits (USDA 1976b, p. 13)
$PGSNFC_{foft}$	Current personal gross saving by continuing farm operator families used to finance nonfarm capital accumulation (equation (15))
$\Delta NMFA_{foft}$	Current net additions to time deposits, U.S. savings bonds, and investment in cooperatives by continuing farm operators (equation (16))
$NMFA_t$	Current year-end stock of time deposits, U.S. savings bonds, and investment in cooperatives (USDA 1976b, p. 13)
$\Delta ONFCA_{foft}$	Current net additions to other nonfarm capital accumulated by continuing farm operator families (equation (17))

household capital items (line 5) reflects the remaining expenses not previously included in $GCFOE_t$ (USDA 1975c). The remaining personal outlay entries in table 1 require specific assumptions and statistical procedures. Line 4, for example, is based in part on the assumption that off-farm income of discontinuing farm operator families is less than fully offset by that of incoming farm operator families by an amount equal to the decline in the number of farms times the average off-farm income earned per family during the year. In addition, this entry assumes that the net cash farm income of discontinuing farm operators who sell to nonfarm proprietors transfering land to nonagricultural uses is also withdrawn.

Line 6 presents an estimate of selected personal outlays for household nondurable goods and services by continuing farm operator families (see table 1, footnote b). Excluded are repairs and operation of household capital items, which are accounted for in line 5, and capital expenditures for household dwellings, household furnishings and equipment, and motor vehicles for household use. The national income accounts treat purchases of consumer durable goods with the exception of dwellings as personal consumption rather than household investment, implicitly assuming that these goods are completely consumed within the year they are purchased (U.S. Dep. Commerce). This study instead advocates including purchases of all household capital goods in the capital finance account where they belong. Equation (5) presents the statistical procedure used to approximate outlays for selected nondurable goods and services by continuing farm operator families. Because of the variable nature of personal disposable income during the 1970s and the timing of crop receipts, outlays for these goods and services are assumed to be given by a fraction of expected rather than actual current personal disposable income, where expected current personal disposable income is given by the average annual flow received during the previous three-year period. Thus, the ratio of outlays for nondurable goods and services, with the exception of those associated with repairs and operation of household capital items, found in a 1973 survey of farm operator families to their expected personal disposable income in 1973 is multiplied by the current expected personal disposable income (USDA 1975a). While this procedure is preferred over those considered for which data are available, annual surveys of personal consumption outlays are clearly necessary to insure the acceptance of this account over time.

The final entry in the account is current personal gross saving by continuing farm operator families (line 7), which is determined residually as shown in equation (6). The reliability of this entry therefore is dependent upon the acceptability of the statistical procedures and assumptions employed above. The level of gross saving by farm operator families for 1973, however, should be reliable due to the presence of survey results for personal consumption (USDA 1975a). While alternative procedures and assumptions modify these estimates somewhat, their impact on personal gross saving is likely relatively minor.

Usefulness of the Account

The information on financial outcomes provided by a personal income and outlay account for selected target groups of farm production sector participants is a necessary input to aggregative analyses of their financial position. The account presented in table 1 allows the analyst, for example, to examine the personal consumption behavior of farm operator families. Furthermore, personal gross saving, when added to the proceeds from capital sales and retained farm earnings of individual and family-held farm corporations, identifies the total sources of internal capital finance available to this target group of sector participants.

Among the more interesting comparisons possible with the information presented in table 1 is the ratio of personal gross saving to personal income of farm operator families adjusted for withdrawals by discontinuing farm operator families. This "saving ratio" rose from approximately 39% in 1970 to a high of 58% in 1973 when income from farm production rose sharply. The saving ratio fell back to the 43% level in 1974 and to 41% in 1975 when prices paid for household nondurable goods and services rose dramatically while personal income fell.

Simunek presented an estimate of saving computed residually in a farm capital finance account whose scope was limited to the finance of farm production capital purchases and net additions to farm inventories, currency, and commercial bank deposits. According to him net saving was $4.7 billion in 1973, while gross saving was $10.7 billion, some 70% below the estimate of personal gross saving by farm operator families reported in table 1.

Simunek states, "New research areas and priorities are established by the capital finance account. For example, the estimate of saving permits identification of consumption behavior of the farm sector via the consumption function" (p. 540). While his statement taken by itself is theoretically correct, its application to his estimate of gross saving would lead to measurement error in econometric studies of consumption behavior of farm production sector participants. This is true for two reasons. First, his estimate of a gross saving of $10.7 billion in 1973 represents only that portion of gross saving that is used to finance farm capital accumulation of $15 billion, ignoring that portion used by sector participants to finance household capital purchases and nonfarm investment. Secondly, this account includes the gross saving of all farm production sector participants used to finance farm capital accumulation rather than the saving and investment of a particular unique group of sector participants such as farm operator families. While both account designs are useful for selected purposes, it is important for the analyst to understand their inherent differences and that the estimate of gross saving given by Simunek does not permit the identification of personal consumption or total gross saving of farm production sector participants.

A major question left unanswered by the personal income and outlay account is how farm operator families allocate their personal gross saving between farm and nonfarm investments. To address this question, an additional account is needed that measures sources and uses of funds on capital account for farm operator families.

Capital Finance Account

The purpose of a capital finance account for farm production sector participants is to report the amount of internal and external sources of funds used to finance the capital they have accumulated on and off farms during the year. Many of the reasons cited earlier for disaggregating the sector personal income and outlay account by selected target groups of sector participants are equally applicable to the sector capital finance account. One would expect farm operator families as a group, for example, to exhibit a different portfolio balancing behavior than other groups such as nonoperator landlords. The estimate of personal gross saving by farm operator families presented in table 1, for example, would be shown as a source of internal finance in a capital finance account for this target group.

Like the sector sources-and-uses-of-funds statement, which is predicated on the convention that total sources equal total uses of funds, the capital finance account requires that total capital accumulation equal total capital finance.[3] Capital accumulated on

[3] The capital finance account is quite similar in design but narrower in scope than the sector sources-and-uses-of-funds

Table 3. Capital Finance Account, Continuing Farm Operator Families, Current Dollars, 1970–75

Item	1970	1971	1972	1973	1974	1975
	Billion $					
Capital accumulation						
Farm capital accumulation						
1. Purchases of machinery and motor vehicles for business and household use minus trade-in value	5.3	5.3	6.2	8.1	8.6	9.2
2. Purchases of capital improvements to farm real estate	2.2	2.3	2.1	2.8	3.8	3.5
3. Purchases of farm real estate minus sales	3.2	4.5	6.5	8.6	7.1	7.4
4. Net additions to household furnishings and equipment	0.2	0.7	1.1	0	0.3	0.3
5. Net additions to farm inventories	0	1.4	0.9	3.4	−1.3	2.9
6. Net additions to currency and demand deposits	0.2	0.2	0.4	0.3	−0.2	0
Total farm capital accumulation	11.1	14.4	17.2	23.2	18.3	23.3
Nonfarm equity capital accumulation[a]						
7. Net additions to time and savings deposits, U.S. savings bonds, and investments in farm cooperatives	0.9	1.5	1.5	2.0	1.5	1.9
8. Net additions to equity in life insurance reserves, individual retirement accounts, stocks and bonds, and other nonfarm capital	3.6	3.0	7.3	19.6	13.9	6.8
Total nonfarm equity capital accumulation	4.6	4.5	8.8	21.6	15.4	8.7
Total	15.7	18.9	26.0	44.8	33.7	32.0
Capital finance						
9. Farm capital borrowing minus principal repayment	3.0	5.1	7.8	11.0	9.0	9.1
10. Retained farm earnings of individual and family-held farm corporations	−0.1	0	0.1	0.2	0.3	0.3
11. Total personal gross saving	12.8	13.8	18.1	33.6	24.4	22.6
Total[a]	15.7	18.9	26.0	44.8	33.7	32.0

[a] Due to a lack of data on external finance of nonfarm capital accumulation, the account is restricted to nonfarm equity capital accumulation and finance.

farms during the year by farm operator families can include purchases of farm real estate, farm production capital goods, farm household capital goods, and net additions to farm inventories and cash balances, while capital accumulated off farms would include stocks and bonds, individual retirement accounts, life insurance reserves, nonfarm real estate, and other forms of nonfarm investments.[4] Total capital finance, on the other hand, would include personal gross saving, the proceeds from the sale of capital by continuing farm operator families, retained farm earnings of individual and family-held farm corporations, and the external funds supplied by lenders, limited partners, and others. To enhance the usefulness of the account, the accumulation and finance of farm production, farm household, and off-farm capital should be separately identified in the account.

Table 3 presents a capital finance account for farm operator families during 1970–75. Because of several data limitations identified in the following section, the estimated account takes on a somewhat different design from that desired. Readers wishing to proceed directly to a discussion of the usefulness of this account may skip the following section.

Estimation of the Account

An attempt to focus specifically on the capital accumulation and finance of farm operator families is seemingly thwarted by the fact that farm capital accumulation and finance of nonoperator landlords is not identified apart from that of farm operator families in the present sector economic accounts (USDA 1976b, c). Fortunately, an estimate of farm capital accumulation and finance by Penson and Williams based on a 1970 national survey does distinguish between these two groups of sector participants. These survey results can be used to focus specifically

(SAUF) statement; that is, the SAUF statement can go beyond the capital finance account to show how business outlays on current account, for example, are financed when information on gross flows of production credit is available from all lender groups. Because these data are not available, financial analyses utilizing sector SAUF statements such as that proposed by Melichar are limited to the financing of financial and nonfinancial transactions on capital account, thereby eliminating any differences in the scope of these estimated SAUF statements and the capital finance account.

[4] Net additions to farm inventories includes crop inventories stored on and off farms.

on farm operator families if the fraction of farm capital accumulation and finance accounted for by nonoperator landlords in 1970 is equally valid for 1971–75. The following equations (variable description presented in table 2) document the statistical procedures and data sources used to estimate selected entries in the capital finance account presented in table 3:

$$(7)\quad TPMV_{foft} = (BPTK_t/r_{btk}) + (BPAO_t/r_{bao}) + BPTE_t - ((BPTK_t + BPAO_t + BPTE_t)(r_{nopc})),$$

$$(8)\quad PRECI_{foft} = (PRECI_t)(1 - r_{nopr}),$$

$$(9)\quad NPRE_{foft} = (TVET_t)(r_{baft}) - (TVET_t)(r_{saft})(r_{afr}),$$

$$(10)\quad \Delta HHF_{foft} = ((HHF/P)_t - (HHF/P)_{t-1} + ((HHF/P)/N_{fof})_{t-1}(\Phi(\Delta N_{foft})))(PP_{hft}),$$

$$(11)\quad \Delta CDD_{foft} = CDD_t - CDD_{t-1} + (CDD/N_{fof})_{t-1}(\Phi(\Delta N_{foft})),$$

$$(12)\quad TFCA_{foft} = (TPMV + PRECI + NPRE + \Delta HHF + \Delta I + \Delta CDD)_{foft},$$

$$(13)\quad \Delta NMFA_{foft} = NMFA_t - NMFA_{t-1} + (NMFA/N_{fof})_{t-1}(\Phi(\Delta N_{foft})),$$

$$(14)\quad \Delta ONFCA_{foft} = TCF_{foft} - TFCA_{foft} - \Delta NMFA_{foft},$$

$$(15)\quad TCF_{foft} = (CB - APP)_{foft} + PGS_{foft} + RFCE_{foft},$$

and

$$(16)\quad (CB - APP)_{foft} = (\Delta REDO_t + (TVET_t)(r_{do})(1 - r_{afr}))(1 - r_{noprd}) + (\Delta NREDO_t)\quad (1 - r_{nopnd}) + (NREDO/N_{fof})_{t-1}(\Phi(\Delta N_{foft})).$$

Total capital finance in table 3 consists of net farm capital borrowing, retained farm earnings of individual and family-held farm corporations, and personal gross saving of continuing farm operator families. The procedure for estimating net farm capital borrowing presented in equation (16) reflects an attempt to isolate the net farm capital borrowing of continuing farm operator families. The last term in this equation assumes that discontinuing farm operator families have an amount of non-real estate debt equal to the average non-real estate debt per farm operator family. Some will have no non-real estate debt outstanding at the time of sale, while still others will have substantially more than average.[5]

Omitted from the account is the net inflow of external equity finance supplied by such nonfarm investors as limited partners, which is used to finance capital accumulated on farms by continuing farm operator families. Because of a total absence of data to even approximate this net inflow of funds, increases in this external source of finance to farm operator families are assumed to be exactly offset by nonfarm investor withdrawals. In years of net inflows, the above assumption understates $\Delta ONFCA_{foft}$, while the opposite is true in years of net outflows. One insight to inflows of external equity capital to finance farm capital accumulated by farm operator families is provided by Scofield in a study of agricultural ventures filed with the Securities and Exchange Commission during 1970–71. Scofield reported that more than one-half of these ventures involved limited partnership interests and that the majority of these ventures were to raise capital for either cattle feeding operations or to establish citrus groves, nut orchards, and vineyards. Because uses of funds to establish citrus groves, nut orchards, and vineyards are treated as current expenses in *Farm Income Statistics* and are not identified apart from legitimate current operating expenses, they are not included in total farm capital accumulation in table 3. Thus, external equity capital used to finance these uses of funds would have to be excluded from the capital finance account in any event. Furthermore, not only will a portion of external equity finance of net additions to commercial feedlot inventories be netted out in an annual capital finance ac-

[5] If one instead assumed that discontinuing farm operator families were comprised entirely of older operators of smaller units with zero non-real estate debt at the time of sale, line 2 would decline by a maximum of $0.3 billion in any one year during 1970–74. This, in turn, would increase line 1 and decrease lines 10 and 12 by an equal amount.

count but the external equity capital supplied to general partner-farm operators through these limited partnership interests may represent only a minor portion of their total finance. Dietrich, Martin, and Ljungdahl showed that feed companies, meat packers, retailers, doctors, lawyers, teachers, and other nonfarm custom clients at commercial feedlots accounted for less than 20% of total cattle placements in Texas.[6] Given that net additions to livestock inventories are a relatively small portion of total farm capital accumulation, one can conclude that the lack of data on net inflows of external equity capital may not be as damaging to the creditability of line 12 in table 3 as one might expect. This does not diminish the need for data on this source of external finance to farm operator families.

The proceeds from the sale of farm real estate by continuing farm operator families are assumed to be used to buy other farm real estate so as to avoid capital gains taxes. This assumption, which is similar to that employed by Melichar, is reflected in the capital finance account by reporting farm real estate purchases by continuing farm operator families net of sales (line 3). Thus, the account shows the additional funds necessary to complete these transfers.[7] Purchases of machinery and motor vehicles for business and household use (line 1) are not identified separately in the account since the finance of capital on farms is not identified by the purpose of the loan (USDA 1976b, c); that is, the finance of autos for business use is not separated from the finance of autos for farm household use. In addition, the value of machinery traded in at the time of sale is not identified apart from the purchase price of the new machine (USDA 1976c, p. 52). Finally, a lack of information on gross flows associated with lines 4, 6, and 7 for continuing farm operator families necessitates the use of net flows adjusted for withdrawals by discontinuing farm operator families instead.

Because of a lack of data on the external finance of capital accumulated off farms by continuing farm operator families, the coverage of nonfarm capital accumulation in table 3 is limited to net additions to equity in nonfarm capital. Net additions to time and savings deposits, U.S. savings bonds, and investments in farm cooperatives are estimated from equation (13), while net additions to equity in other forms of nonfarm capital are determined residually as shown in equation (14).

It should be clear from a review of the procedures and assumptions outlined above that more frequent surveys pertaining to selected entries in the account are required to assure its acceptance. The account also represents a first attempt to focus specifically on continuing farm operator families. Further information on the asset holdings and debt outstanding of continuing versus discontinuing farm operator families is needed to refine the estimates from equations (10), (11), (13), and (16). Finally, the strengthening of several published data series such as $PRECI_t$ in the present sector economic accounts directly benefits the capital finance account as well.

Usefulness of the Account

While the design of the capital finance account presented in table 3 differs from that desired due to data limitations, it does provide much of the information essential for aggregative analyses of financial outcomes. Table 4 presents several analytical ratios that identify the relative importance of internal versus external farm capital finance and farm versus nonfarm use of total personal gross saving by continuing farm operator families based on the estimates presented in table 3.

The relative importance of net capital borrowing as a source of farm capital finance has practically doubled during 1970–75. Continuing farm operator families are estimated to have financed 49% of their farm capital accumulation with borrowed funds in 1974 as compared to only 27% in 1970. Because of this, the percentage of farm capital accumulation internally financed declined from 73% in 1970 to 51% in 1974. In 1975 continuing farm operator families increased the portion

[6] Of those ventures to raise capital for beef-breeding herds, most involved direct sales rather than limited partnership interests. Further, these buyers concentrated on small numbers (five to ten) of purebred or exotic breeding cows rather than large commercial cow herds.

[7] The statistical procedure used to estimate the value of real estate sales by continuing farm operator families will overstate this source of funds if the fraction of farm operators remaining active after the sale is less than their fraction of the total value of real estate sold. Because of an absence of data on the number of acres and value per acre of real estate sold by farm operators remaining active after the sale, further adjustment to this procedure is not attempted. Given the relatively small value of the sales estimate, any additional adjustment would likely have little effect on the conclusions drawn from an analysis of the account.

Table 4. Selected Analytical Ratios, Continuing Farm Operator Families, 1970–75

Item	1970	1971	1972	1973	1974	1975
Percentage of farm capital accumulation financed by						
Internal finance[a]	73.0	64.6	54.4	52.8	50.8	60.9
External finance	27.0	35.4	45.6	47.2	49.2	39.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
Percentage of total personal gross saving used to finance						
Farm capital accumulation	63.3	66.4	50.3	35.2	36.5	61.1
Nonfarm equity capital accumulation	36.7	33.6	49.7	64.8	63.5	38.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a] Personal gross saving used by continuing farm operator families plus retained farm earnings of individual and family-held farm corporations.

of their farm capital accumulation financed with internal funds to 61%. This comparison by itself does not tell the whole story because it fails to indicate what portion of the total personal gross saving of continuing farm operator families was used to finance nonfarm capital accumulation. Given the assumption that net additions to equity in nonfarm capital by continuing farm operator families are financed entirely from their personal gross saving, clearly these sector participants allocated a declining portion of their total personal gross saving to financing farm capital accumulation during 1970–74. Table 4 shows, for example, that the portion of total personal gross saving used to finance nonfarm capital accumulation rose from 37% in 1970 to a high of 65% in 1973.

To fully assess why continuing farm operator families in general would increase their relative use of borrowed funds to finance farm capital accumulation while at the same time increasing their internal finance of nonfarm capital accumulation is beyond the scope of this study. One can hypothesize that increased variability of farm product prices, coupled with shortages of such production inputs as tractors, the unprecedented levels of personal gross saving, and the dramatic increase in the yields on short-term government securities, would partially explain this shift in portfolios during 1973–74. The reversal of this trend in 1975 coincided with yields on short-term government securities falling sharply and farm product prices stabilizing somewhat.

The results presented in table 4 also suggest the need to disaggregate the capital finance account for this group of sector participants by farm type, size, and tenure groups to explain properly these financial outcomes. The separation of farm operator families associated with livestock farms from those associated with crop farms may help explain the 1974 estimates presented in table 4. Such information should be extremely useful to policy makers who are concerned with the potential impact of their decisions on the financial position of farm production sector participants. For example, at least a part of the current withdrawals by farm operator families to finance nonfarm investments would conceivably be diverted to finance farm capital accumulation in times of emergency or lessened product market uncertainty.

Simunek recently proposed a capital finance account that was limited to the finance of farm production capital accumulation. Capital accumulation in his account is limited to farm production capital expenditures by all groups of sector participants plus net additions to farm inventories, currency, commercial bank deposits, U.S. savings bonds, and investments in cooperatives by farm operator families. The coverage of capital finance is limited to the net farm capital borrowing of all sector participants, gross proceeds from real estate transfer by continuing and discontinuing proprietors, and the residual estimate of saving discussed earlier. The usefulness of this account is limited to a demonstration of the relative importance of capital borrowing in financing farm production capital accumulation. It fails to provide an insight to the complete range of transactions in investment portfolios of farm production sector participants, prohibiting testing of hypotheses regarding the determinants of their portfolio balance.

The theory of portfolio balance suggests that investors simultaneously consider the complete range of portfolio choices (farm and nonfarm) available to them when formulating their desired levels of investment in physical and financial assets (Penson 1972). The capital finance account presented in table 3 attempts to provide this information for continuing farm operator families. The development of additional capital finance accounts for the remaining groups of farm production sector participants would provide the same information as the Simunek account and more. When laid side by side as column vectors in a capital finance matrix, the capital finance accounts for each group of sector participants show the relative contribution to total farm capital accumulation and finance made by each target group. Furthermore, this capital finance matrix provides a better insight to the importance of farm capital accumulation in relation to the total capital accumulated by each group, providing a more meaningful data base for future econometric studies of investment behavior of farm production sector participants.

Summary and Conclusions

This paper proposes the addition of two new accounts to the farm production sector economic accounting system, which together provide needed information on financial outcomes for farm operator families. A personal income and outlay account and capital finance account are estimated for this group of farm production sector participants based upon presently available data to illustrate their potential usefulness. The statistical procedures and data sources used to estimate the accounts are presented to identify existing data deficiencies and facilitate reestimation for those preferring alternative assumptions or procedures. More frequent surveys related to specific entries are suggested to assure the acceptance of these accounts over time and permit econometric analyses of the consumption, investment, and borrowing behavior of farm operator families apart from that of other sector participants.

Estimation of capital finance accounts for each of the remaining groups of sector participants would permit the construction of a sector capital finance matrix. This accounting matrix would show the relative contribution of each target group to total farm capital borrowing and total farm capital accumulation. In addition, it would highlight the relative importance of this source and use of funds to each target group.

It was previously stated that the adequacy of an economic accounting system can be judged by whether it can accurately and fully portray the operation and performance of the economic system and the welfare of its participants. By adopting the economic accounts proposed in this study and seeking ways to more adequately measure selected entries including a more complete treatment of nonfarm capital accumulation and finance of farm operator families, the sector economic accounting system can provide analysts and policy makers with a more complete portrayal of the changing financial position of this group of farm production sector participants.

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The Economics of Upgrading Seventy-one Branch Rail Lines in Iowa

C. Phillip Baumel, John J. Miller, and Thomas P. Drinka

Proposed abandonment of branch rail lines in rural areas has stimulated considerable concern over the impact of abandonment on shippers, receivers, and rural communities. The purpose of this paper is to present estimates of the benefits and the costs of upgrading seventy-one branch rail lines. A benefit-cost analysis is used to compare the net benefits with the net costs of upgrading the rail lines. Separate models are utilized to estimate the benefits to grain shippers, fertilizer shippers, and shippers and receivers of all other products from upgrading the branch lines. Benefit-cost ratios are presented for six alternative solutions.

Key words: benefit-cost ratios, grain transportation, rail abandonment, railroads.

Until around 1900, railroads were the dominant mode of transportation in the Midwest. Since then, the development of motor vehicles, highways, airlines, and improvements in waterway transportation have changed the transportation system. As a consequence, railroad officials claim that they now have too many rail lines that are no longer profitable and are sapping financial resources needed to improve the efficiency of the railroad system.

Shippers and communities along branch rail lines view the situation differently. The railroad still is vital, they say, to the survival of farmers, businesses, and communities. But little factual evidence is available to resolve the conflict. Railroads generally cite their poor financial situation as evidence for branch line abandonment. Community leaders cite past traffic as evidence for continued operation of the line.

Public discussions and some studies of the expected impact of rail abandonment implicitly assume that product flows must remain as they have been in the past (Poth). Consider the problem of moving products into or out of Community X located on the branch line in fig. 1. It is 39 miles from Community X to Mainline Junction. Traditional analyses generally assume that should the branch line be abandoned, products must continue to be moved between Community X and the final destination by truck at a considerable increase in cost. Such an analysis ignores other possibly less costly alternatives. For instance, Community X is 5 miles west of the north-south main line serving Community Y. Products leaving Community X could be moved by truck to Community Y and then to the final destination by rail. Road miles would then constitute only a small fraction of the total miles required to move material from Community X to the final destination. Thus, an optimal flow pattern might suggest that it would be less costly to truck 5 miles than to maintain 39 miles of comparatively lightly used rail line.

The optimal flow pattern may be even more dramatic for grain. For instance, a farmer located 4 miles south of Community X could take his grain to the subterminal located on the main line at Community Z by traveling an additional 2 miles rather than going to the elevator at Community X. Since a large portion of the total cost of transporting grain from farm to market is fixed costs that include the costs of owning the tractor, wagon, or truck and the cost of loading and unloading time—regardless of where the grain is moved, the additional time and cost of the extra 2 miles of movement is relatively small compared to the costs of maintaining the 39 miles of lightly used rail lines.

The purpose of this paper is to present

C. Phillip Baumel is a professor of economics, John J. Miller is a predoctoral research associate, and Thomas P. Drinka is a postdoctoral research associate at Iowa State University, Ames.

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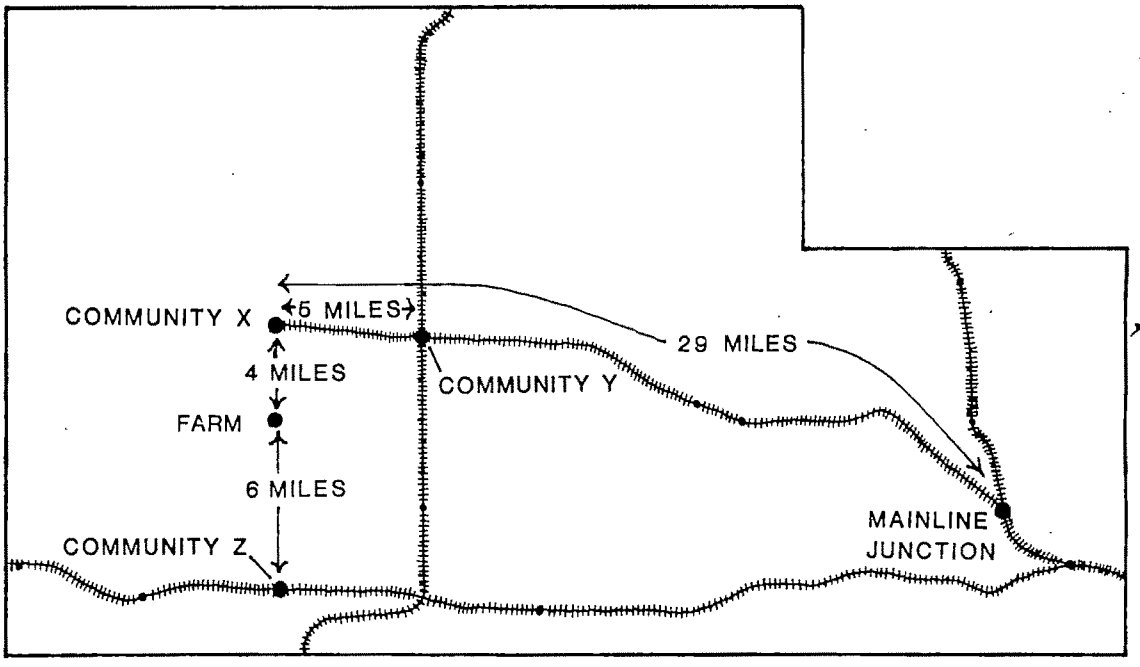


Figure 1. Illustration of possible product flows with a branch line upgraded and alternatively abandoned

estimates of the costs and benefits of upgrading and maintaining branch rail lines in Iowa so that better decisions might be made in developing a transportation system suited to farm, business, and community needs. In this analysis, costs are minimized and/or revenues are maximized under upgrading and abandonment alternatives.

Method of Analysis

Seventy-one branch rail lines are included in the study. These lines represent 32.9% of the total rail line mileage in Iowa. Most of the lines are lighter volume lines in relatively poor condition and may be considered as potential candidates for abandonment. For this analysis, the state is divided into eight "districts," primarily to reduce the number of possible combinations of rail line abandonment.

A benefit-cost analysis is used to evaluate the economics of upgrading the study lines. The benefits from upgrading are defined as the total annual transportation and handling cost saving to grain shippers, fertilizer receivers, and shippers and receivers of other products if the line is upgraded rather than abandoned. The costs of upgrading are defined as the total annualized cost of upgrading the line to 263,000-pound carrying capacity and to Federal Railroad Administration Class II standards—maximum speed of 25 miles per hour—plus the fixed cost of maintaining the line at that level of upgrading. With the declining number of 40-foot, narrow-door boxcars and the increasing use of 100-ton hopper cars, light branch lines with carrying capacities of less than 263,000 pounds are no longer functional for today's rail transportation.

The following benefit-cost ratio, obtained by dividing the total benefits from upgrading the line by the annualized upgrading and fixed maintenance costs, is computed for each of the rail lines:

$$(B/C)_r = \{[GRNC_{r_d-1} - GRNC_{r_d}] + [FC_{r_d} - FC_{r_d-1}] + [OPC_{r_d} - OPC_{r_d-1}]\} \{[(U_r - SU_r) + SA_r][\frac{i(1+i)^n}{(1+i)^n - 1}] - SF_r[\frac{i}{(1+i)^n - 1}] + FMC_r\}^{-1}$$

where r is rail line index, $(r = 1, 2, \ldots, 71)$, B/C is benefit-cost ratio, d is index of dis-

tricts within Iowa, ($d = 1, 2, \ldots, 8$), R is total number of study rail lines or segments of lines evaluated, r_d is index denoting the district rail line network after the rth rail line is theoretically abandoned, designates the rank and number of study lines theoretically abandoned in district d and maps on a one-to-one basis with the rth study line or segment of line in district d, ($r_d = 1, 2, \ldots, R_d$), $GRNC$ is maximum total grain revenue from the sale of grain, net of all transportation costs from farm to market, variable nonfarm storage, and variable handling and annual facility investment costs, FC is minimum total fertilizer transportation and handling costs for transporting the retail fertilizer requirements from the sources of fertilizer supplies to retail locations, OPC is minimum additional transportation and handling costs for products other than grain and fertilizer that originate or terminate on study lines theoretically abandoned, U is total gross upgrading cost, SU is total value of the salvageable material removed during upgrading, SA_r is salvage value foregone if the rth rail line is upgraded rather than abandoned, SF_r is estimated future salvage value of the rth rail line if it is upgraded, FMC is fixed maintenance cost per year, i is interest rate per annum, and n is years of service life.

All study rail lines within a district are assigned a rank (r_d) based upon the ratio defined as the total cars originating and terminating on the rail line from 1 January 1972 to 31 August 1974 divided by the annualized upgrading and fixed maintenance cost of the line. The rail line with the smallest ratio ($r_d = 1$) is the first line to be theoretically abandoned. Then, the line with the next smallest ratio ($r_d = 2$) is considered for abandonment under the assumption that the previously analyzed line has been abandoned. This process continues for all rail lines in each district. When a study line is contained in more than one district, the benefits from each segment of the line are added together to obtain the total benefits of upgrading that line.

In the analysis, product flows for each district are first optimized to maximize the net revenue from grain—corn and soybeans—and to minimize the transportation and handling costs of dry fertilizer and other products, assuming that a given rail line is upgraded. The optimal computer solution identifies the "best" system of transporting these products with the rail line upgraded, given grain prices at all markets and all transportation and handling costs from origin to destination. Then, the flows are reoptimized under the assumed abandonment of the rail line. In effect, the flows are reoptimized using a reduced transportation cost matrix consisting of only truck, truck-barge, truck-rail, and truck-rail-barge cost coefficients for the shippers and receivers on the abandoned line. This second solution identified the "best" system of transporting products with the particular rail line abandoned. The difference between these two computer solutions is the economic benefit of upgrading the rail line. Essentially, the estimated benefits of upgrading are the total annual transportation and handling cost savings to grain shippers, fertilizer receivers, and shippers and receivers of other products if the line is upgraded rather than abandoned.

Grain Model

The nature and scope of the grain distribution system in Iowa where economies of large grain shipments exist suggest a method of analysis based on a transshipment plant-location model. Transshipment plant-location models are used to determine the optimal structure of an industry when transportation costs are incurred from origin to plant and from plant to destination.

Stollsteimer developed a plant-location model to determine the optimal number, size, and location of plants when either transport costs from origins to plants or transport costs from plants to destinations are relevant. Extensions of the Stollsteimer model, incorporating both the transport cost from origins to plants and plants to destinations, were later developed (Baumel et al. 1973, Ladd and Lifferth). The model used in the present analysis is a variation of these extensions and incorporates volume constraints on destinations.

The grain model is based on the following assumptions. The quarterly supply of corn and soybeans at each origin is known. Each grain producer in each district has the option of shipping his grain either to a country elevator or to a subterminal elevator. A country elevator stores and ships grain to a subterminal elevator and/or to "final destinations" including export ports and domestic

processing markets. A subterminal can store and ship to final destinations.

A country elevator may transport grain to a subterminal by truck or to a final destination by truck, truck-barge and, depending upon the availability of rail service, rail or rail-barge. Country elevators cannot utilize multiple-car rail shipments in excess of ten cars because of rail or elevator load-out capacity constraints. Grain received by subterminals may be shipped to final destination in multiple-car rail shipments, truck, rail-barge, or truck-barge. Multiple-car rail shipments from subterminals can be twenty-five cars or more.

Quarterly demand prices for grain at each destination are known and vary by time and commodity. Per unit transportation costs are known and also vary by commodity and time. Variable handling costs vary by commodity, time, and mode of shipment. The quarterly grain prices, net of transportation and variable handling costs, determine where an origin, country elevator, or subterminal will ship the grain.

Some grain distribution facilities, including elevators, subterminals, and rail lines, exist at the beginning of the planning horizon, 1 January 1975. Existing country elevators continue in operation and may be expanded into subterminals, new subterminals may be constructed, and rail lines may be abandoned.

Existing storage facilities of elevators are always used to capacity during the harvest quarter before any elevator expands. Existing grain storage capacity at an elevator, as used in this model, is defined as total storage capacity at the elevator, minus that portion of storage capacity used for working space and back-to-farm shipments of grain. Total construction and/or expansion costs, therefore, vary by location and by size of the existing facility.

Net revenue to producers is maximized subject to the following constraints: (*a*) existing storage facilities of country elevators and subterminals are filled to capacity in the harvest quarter before storage capacity is allowed to expand at any elevator or subterminal, (*b*) Iowa corn and soybean processors receive a quantity of grain equaling 90% to 100% of their projected 1980 processing capacity, and (*c*) the quantity of each commodity shipped from a district each quarter is predetermined.

The objective function of the model is to maximize net revenue to producers within a district under various rail line networks. Net revenue is defined as the income received at final destination minus all handling costs other than previously sunk costs and minus all transportation costs from farm to final destination. The model determined the optimal number of subterminals, the optimal locational pattern of subterminals, and the optimal flow of grain from origins to final destinations, given the rail line network.

The procedure used to determine the maximum total net revenue to producers from the sale of the projected 1980 volume of grain in a district for a given rail line network is divided into three steps. Step 1 selects the minimum-cost routing of each grain from origins to existing country elevators and subterminals in the district such that existing storage facilities are used to their capacity during the harvest quarter. Step 2 selects the routing of each grain from origin to final destination that maximizes the revenue to grain producers net of variable transportation and handling costs, under a given locational pattern of subterminals and a given rail line network in the district, subject to volume constraints on Iowa grain processors. Step 3 selects the number and locational pattern of subterminals that maximize the net revenue to grain producers for a given rail line network in the district. A rigorous description of these algorithms is presented in Baumel, Miller, and Drinka.

Fertilizer Model

The benefits to fertilizer receivers within a district under alternative combinations of branch rail line abandonment are estimated in essentially the same manner as for grain shippers. A modified Stollsteimer transshipment model is used to minimize the cost of transporting the projected 1980 dry fertilizer requirements of retail fertilizer dealers in a district from the supply points to the existing retail locations under various rail line networks. The model determines the optimal number and location of fixed conveyor facilities for transshipping fertilizer and the optimal flows of dry fertilizer from supply points to retailers, given the rail line network, under the following assumptions: (*a*) the demand for fertilizer at each location is fixed and

known; (*b*) there is an infinite supply of fertilizer at specific supply locations; (*c*) phosphorous supplies are located in Florida, potash originates in Saskatoon, Saskatchewan, Canada, urea is manufactured or imported at Donaldsonville, Louisiana, and ammonium nitrate can originate in Clinton, Iowa, or Beatrice, Nebraska; (*d*) fertilizer can be moved from Florida and Louisiana to warehouses and retail locations by rail, rail-truck, rail-barge-rail, or rail-barge-truck or from Houston, Texas, by rail or rail-truck; (*e*) potash and ammonium nitrate can be transported to warehouses or retail locations only by rail, truck, or rail-truck; (*f*) retailers located on an abandoned line can obtain fertilizer by truck from a warehouse or directly from a rail car at a nearby rail line by transferring the fertilizer into a truck through a conveyor; (*g*) potential sites for conveyor facilities include all retail fertilizer locations having at least 900 feet of rail siding; (*h*) all existing fertilizer warehouses are available for use and no new warehouses will be built at sites other than at existing warehouse locations; and (*i*) all existing fertilizer retail sites will remain in operation even with rail abandonment because of the high cost of delivering fertilizer to farms.

Other Products Model

The upgrading benefits derived by shippers and receivers of all other products are also estimated. The "other products" model determines the optimal flow of each commodity group under alternative patterns of rail line abandonment by minimizing the cost of transporting the projected 1980 quantity of each commodity group from locations with rail service to receivers on abandoned lines and from shippers on abandoned lines to locations with rail service. This model is based upon the following assumptions: (*a*) the number and location of other product shippers and receivers located on study lines is given; (*b*) the origin or final destination of each commodity group shipped by rail to each receiver or shipper located on a study line is the same after abandonment of the receiver's or shipper's rail line as before abandonment; (*c*) the quantity of each commodity group shipped by rail to and from each receiver and each shipper located on the study lines is known; (*d*) other products can be moved by truck to receivers and from shippers located on abandoned study lines; (*e*) the quantity of inbound products to receivers on abandoned lines moves by rail from each origin to the nearest location with rail service, and the products are unloaded from the rail car onto a truck and moved to the receiver; likewise, products from shippers are moved to the nearest location with rail service by truck, unloaded from the truck onto a rail car, and moved to the final destination; and (*f*) the rate at which each commodity group is shipped by rail from the location with rail service nearest to the abandoned receiver or shipper is equal to the rate at which each commodity group is currently shipped if his rail line is upgraded. This latter assumption is basically consistent with the real world, where many "other products" move under class or group rates.

Data

All transportation, handling, and facility investment cost data used in the grain, fertilizer, and other product models are in late 1974 price levels. The quantities of grain, fertilizer (Baumel et al. 1974), and other products requiring transportation are projected to 1980. The total amount of projected traffic is substantially larger than the 1972–74 levels. Iowa grain processing demand is also projected to 1980.

In the real world and in the grain model, grain prices at final destinations minus handling and transportation costs determine the quantities of grain shipped to each market. The actual delivered prices for corn and soybeans at each of nineteen major markets for corn or soybeans are obtained for the period April 1974 to March 1975. This set of prices is selected for the following reasons: (*a*) it was the most recent price series available at the time of selection; (*b*) the rail rates used in this study were in effect during most of this period; and (*c*) discussions with grain industry executives indicate that the price relationships among markets in effect during this period are similar to expected 1980 price relationships.

Rail rates are obtained for various sizes of shipments from each Iowa origin to each of the nineteen major markets receiving Iowa grain. These rates were at the Ex Parte 305-A rate levels that were in effect from 20 June

1974 to 27 April 1975. Fertilizer rail rates at the Ex Parte 305-A rate level are obtained from each major fertilizer producing area to each retail and warehouse location in Iowa. Barge rates are taken from barge tariffs in effect from April 1974 to March 1975. These barge rates are adjusted by the average quarterly percent of tariff paid by a medium and a large size shipper located on the Middle Upper Mississippi River.

The costs of trucking grain from farms to elevators and subterminals are estimated for each type of vehicle used by farmers to haul grain. In mid-1974, gasoline and diesel prices delivered to farmers and truckers were 50¢ and 45¢ per gallon, respectively. To specify higher fuel prices for truck shipments than for rail or barge shipments, the delivered fuel prices to farmers and truckers were increased to 60¢ and 50¢ per gallon, respectively. The estimated trucking costs were weighted by the proportion of grain hauled from farms to elevators by each type of vehicle. The weights were obtained by examining 15,180 scale tickets for grain delivered by farmers to a local cooperative during May–June 1974 and October–November 1974. The weighted costs are used to estimate the following aggregate cost functions for hauling grain from farms to elevators and subterminals with an empty return: $C_b = \$0.047 + \$0.0013m$ for harvest time, and $C_b = \$0.058 + \$0.0011m$ for nonharvest time, where C_b is cost per bushel, and m is loaded miles. The constant includes the vehicle ownership costs and the cost of loading and unloading the grain.

The estimated cost function for trucking grain from elevators to subterminals is $C_h = \$0.028 + \$0.002m$, where C_h is cost per hundredweight, and m is loaded miles. Similar trucking cost functions are estimated for fertilizer and for other products moved into and out of locations on branch rail lines.

Variable grain handling costs at elevators, subterminals, and barge loading facilities are taken from published research (Schienbein). Handling costs for fertilizer and other products and the costs of expanding grain and fertilizer receiving, storage, and load-out facilities are estimated from data collected from industry representatives.

The costs of upgrading a line are defined as the net cost of upgrading the line at 1974 price levels annualized over a thirty-five year period (Smith) minus the estimated salvage value of the upgraded line at the end of thirty-five years discounted over a thirty-five year period plus the estimated annual fixed maintenance cost—43% of total maintenance cost (U.S. Interstate Commerce Commission)—of the upgraded rail line plus the salvage value foregone if the line is upgraded, annualized over a thirty-five year period.

Two methods of upgrading are used to estimate upgrading costs. First, used 90-pound rail is utilized to replace existing light rail, and interest is computed at 7% per annum. Since 1 January 1976, 90-pound rail is no longer manufactured. There is insufficient used 90-pound rail available to upgrade all branch lines in Iowa in this manner, but some of the lines could be upgraded that way. Therefore, the alternative method of upgrading used in this study is to replace existing light rail with new continuous-welded 115-pound rail; interest on this expenditure is computed at 10% per annum. The two methods provide a range of upgrading costs with actual costs probably falling somewhere between these two extremes.

One set of benefit-cost ratios is based on single-car rates only. A second set is based on the existing multiple-car structure, which includes single-car, 3- to 10-car, 25-car, and 50-car grain rates, and single-car fertilizer rates from each origin to each retail destination and 10-car rates to large fertilizer warehouses. In addition, a third set of solutions is based on estimated single-car, 3- to 10-car, 25-car, and 50-car rail costs for grain and fertilizer along with estimated costs for 85-car trains scheduled to run continuously between Iowa origins and Gulf of Mexico export elevators (Ingram). Referred to as the "85-car cost structure," this system was based upon estimated costs, since 85-car rates are not presently available in Iowa. A set of six benefit-cost ratios is obtained for each of the lines by using the two upgrading costs and under the three rate or cost structures.

Findings

Of the seventy-one study rail lines evaluated, ten produced a benefit-cost ratio greater than 1.00 under one or more of the six possible solutions. These lines, with their benefit-cost ratios, are listed in table 1. The mileage of the nonstudy lines, plus the mileage of the study lines with benefit-cost ratios ≥ 1.00 under

Table 1. Rail Lines with Benefit-Cost Ratios Greater than 1.00

Line	Single-Car Rates		Multiple-Car Rates		Multiple-Car Costs	
	90-Pound Rail	115-Pound Rail	90-Pound Rail	115-Pound Rail	90-Pound Rail	115-Pound Rail
Estherville to Rake			1.19			
Dows to Forest City	3.15	2.17	3.34	2.30	3.58	2.46
Sibley to Iowa Falls	1.89	1.43	2.25	1.71	2.10	1.59
Moorland to Carroll	1.41	1.12				
Altoona to Pella	1.96	1.47	1.95	1.47	2.06	1.54
Winear to Winterset	11.09	6.87	11.09	6.87	11.19	6.93
Beaman to Gladbrook			2.67	1.75	1.32	
Carroll to Harlan	1.23					
Hancock to Oakland	9.67	6.45	9.46	6.31	9.29	6.21
West Liberty to Burlington	1.65	1.12	1.61	1.09	1.60	1.09

the existing multiple-car rate solution with upgrading with used 90-pound rail, represents 72.1% of the total rail line mileage in Iowa. The lines with benefit-cost ratios < 1.00 represent 27.9% of total rail line mileage in Iowa. This latter set of lines originated and/or terminated only 6.1% of the total number of cars in Iowa from 1 January 1972 to 31 August 1974.

Only four rail lines achieved benefit-cost ratios > 1.00 from large grain transportation and handling cost savings. Five lines achieved benefit-cost ratios > 1.00 from large industrial product transportation and handling savings. The remaining line achieved a benefit-cost ratio > 1.00 primarily because it is in rather good condition, requiring a small investment to upgrade it.

The type of rail rate or cost structure had only minimal impact on the number of lines with benefit-cost ratios ≥ 1.00. Both the single-car rate solution and the existing single- and multiple-car rate solution under the 90-pound level of upgrading had eight lines with benefit-cost ratios ≥ 1.00. The multiple-car cost solution utilizing the 85-car continuous train and using 90-pound rail for upgrading had seven lines with benefit-cost ratios ≥ 1.00. Replacing the existing light rail with new continuous-welded 115-pound rail also had only a minimal impact on the number of rail lines with benefit-cost ratios ≥ 1.00. Each rate or cost solution utilizing 115-pound continuous-welded rail had one less line with a benefit-cost ratio ≥ 1.00 than when used 90-pound rail was utilized. However, the use of new continuous-welded 115-pound rail at 10% interest resulted in a substantial reduction on the level of some of the benefit-cost ratios.

The locations of the lines with benefit-cost ratios ≥ 1.00, $0.75 \leq b - c < 1.00$, and $b - c < 0.75$ are shown in figure 2. Only one line within 150 miles of the Mississippi River has a benefit-cost ratio ≥ 1.00. A large industrial plant relying largely on rail transportation is located on this line. Access to water transportation significantly reduces the benefits of upgrading to grain shippers and fertilizer receivers.

Using the existing multiple-car rail rate structure, an analysis was made of the statewide impact of upgrading eight rail lines rather than all seventy-one rail lines. This analysis is presented in table 2. Net savings accruing to shippers if all the rail lines rather than eight rail lines are upgraded total almost \$4.4 million per year. The savings to grain shippers would be about \$1.5 million per year or approximately one-third of the total benefits. The savings to fertilizer dealers would be about \$1.3 million, while shippers and receivers of other products would save about \$1.6 million per year. The reason for the small savings to grain shippers relative to the large volume of grain transported is that the cost of hauling grain an additional mile is relatively small. Furthermore, even if sixty-three rail lines are abandoned, there would still be a large number of rail lines in Iowa, and since grain originates on a large number of widely dispersed farms, grain flows can be easily altered to minimize the additional travel to a rail line.

The annualized cost to the railroads or shippers or taxpayers—if rail line upgrading is assumed as a public expense—would be about \$20 million for upgrading the additional rail lines and for the salvage value foregone if the lines are abandoned. Thus, the

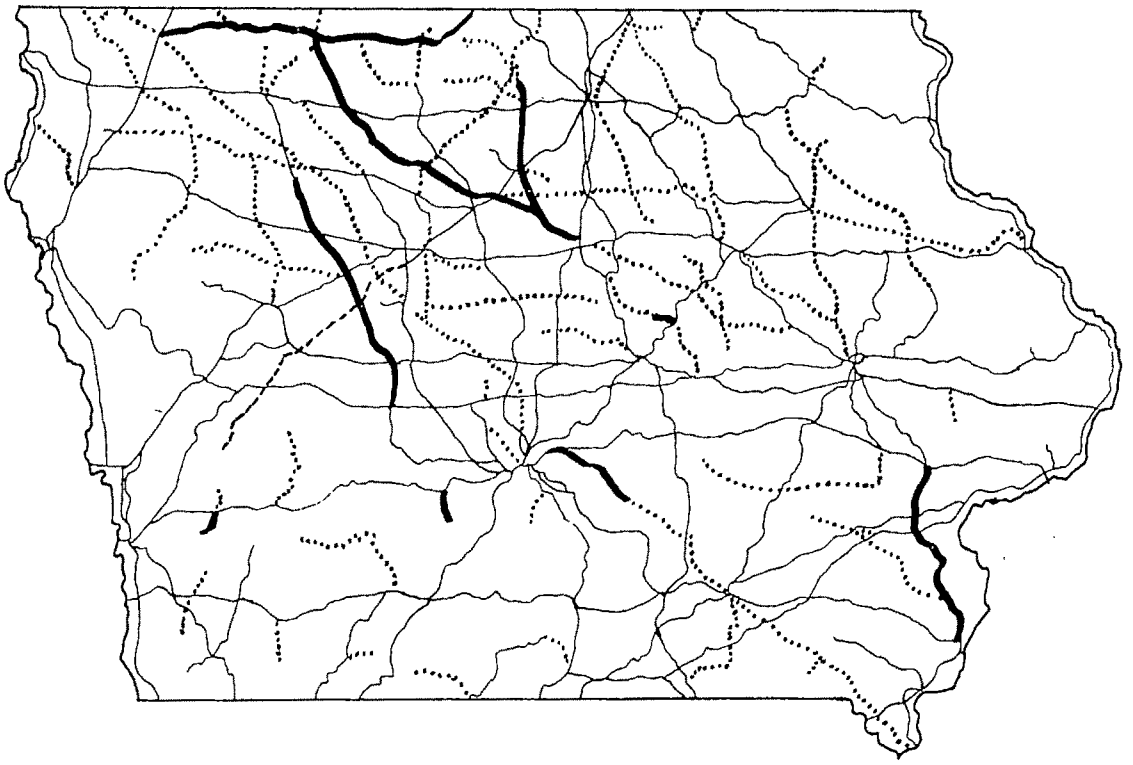


Figure 2. Location of study lines with alternative benefit-cost ratios under the multiple-car rate solution with upgrading to 90-pound rail

—— **Lines not studied**
.... **b − c < 0.75**
– – – **0.75 ≤ b − c < 1.00**
—— **b − c ≥ 1.00**

Table 2. Annual Net Benefits to Shippers and the Annual Costs from Upgrading Seventy-one and Eight Rail Lines

	Optimal Multiple-Car Solution for Lines Upgraded with 90-Pound Rail		
	71 Rail Lines	Eight Rail Lines Having a Benefit-Cost Ratio ≥ 1.00	Net Change
	----------1974 $----------		
Benefits to shippers			
Total grain revenue[a]	4,584,439,800	4,582,954,800	1,485,000
Fertilizer transportation and handling costs at fixed conveyor facilities	46,562,500	47,819,000	1,268,500
Other product transportation and handling costs	0	1,605,449	1,605,449
Total benefits			4,358,949
Net annual upgrading and maintenance costs			
Net upgrading and fixed maintenance costs	18,714,956	1,856,987	16,857,969
Salvage from rail lines abandoned	0	3,227,058	3,227,058
Total costs			20,085,025

[a] Revenue is net of transportation, storage, variable handling and drying costs, and additional grain facility investment costs.

average annual benefits to shippers from upgrading the sixty-three rail lines would be 21.7¢ for each annualized dollar invested in upgrading.

If the state was to shift to the transportation system suggested by the optimal multiple-car rate solution, a number of changes would occur. The increased use of larger multiple-car shipments would put more central and western Iowa grain into the export market. Grain shippers in central and western Iowa located on abandoned lines close to Iowa processors would truck grain short distances to Iowa processors rather than ship the grain by rail to Illinois processors or export markets. Shippers in central and western Iowa located on rail lines continuing in operation would ship to Illinois processors and to export markets by rail rather than truck to local grain processors or to river markets as frequently happens today.

Farmers would increasingly haul grain to facilities with the capacity to load multiple-car shipments. In central and western Iowa, at least—even if the branch rail lines are not abandoned—it appears that some of the state's grain flow will abandon some branch lines. Thus, predicting future grain traffic on branch lines on the basis of past flows may not be a meaningful method of analysis.

Rail abandonment is relatively insensitive to rising fuel costs. Assume that a 450-bushel grain truck using diesel fuel costing 50¢ per gallon obtains four miles per gallon and has an empty return. The fuel cost would be 25¢ per loaded mile or 0.056¢ per loaded bushel-mile. The direct effects of a 100% increase in diesel fuel cost would increase the fuel cost to 0.11¢ per loaded bushel-mile.

Conclusions

Basically, at least one of four conditions is necessary for a branch line to produce a benefit-cost ratio ≥ 1.00: (*a*) the line must carry a sizable volume of grain to produce sufficient transportation savings to pay for the upgrading and maintenance costs—and only four of the seventy-one lines analyzed meet this condition in the study; (*b*) the line must have at least one sizable or several smaller nonagricultural shippers to sustain a large volume; (*c*) the line must currently be in rather good condition so that upgrading costs are minimal; or (*d*) the line must be one of the few remaining branch lines in service within an area, thus inheriting additional volume from stations located on nearby abandoned lines.

One reason that so few Iowa rail lines produce a benefit-cost ratio ≥ 1.00 is that there are so many rail lines in the state. In addition, the rail lines generally are in relatively poor condition, requiring large investments to upgrade the lines. Essentially, the additional distance to get to another rail line in Iowa is short. The incremental cost of moving products to or from another line is small compared with the incremental cost of upgrading the rail line. It is estimated that the annual cost to upgrade and maintain all seventy-one study lines examined is about $18.7 million. Most of the rail lines examined in this study serve small rural agriculturally-oriented communities. Similar analyses in states with fewer rail lines than Iowa or in states with a high level of industrial activity might produce results different than those obtained in this study.

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Empirical Contributions to Basis Theory: The Case of Citrus Futures

Ronald W. Ward and Frank A. Dasse

A futures basis should reflect the marginal cost of physical product plus a risk premium less a convenience yield. However, unique market characteristics may lead to basis bias not explained by the storage theory. An estimate of the basis model for frozen orange concentrate is used to test the theory of storage and to illustrate anticipatory aspects of the basis not included in storage theory.

Key words: basis, biasness, frozen orange concentrate, futures market.

The performance of futures markets and hence their economic usefulness to industries depends on how well the markets react to industry fundamentals. Market performance is measured in part through an analysis of the basis. Using the basis as an index of performance follows, since basis patterns are the key to commercial utilization of futures contracts. If the basis cannot be explained, then there is reason to question both the market's performance and economic usefulness.

Futures basis has historically been judged by how well it reflects the market fundamentals, i.e., the theory of storage. Yet, the basis may yield discounts or premiums as it reflects anticipation of future events or at least the potential for such events. If this potential is seasonal, then the basis may have a built-in bias. Failure to account for bias generally leads to ineffective hedging and hence a judgment of poor performance. In contrast, if the anticipatory effect is incorporated into the basis model, then the market can be judged recognizing deviations from the theory of storage.

The literature on basis theory is reasonably well developed from a theoretical framework and somewhat less so empirically. In addition, many components to a basis model are unique to the specific contract studied. This uniqueness becomes more evident as new contracts such as frozen concentrated orange juice (FCOJ) are added to the list of commodities and products traded (Ward).

Frozen concentrated orange juice futures is a relatively new contract and represents an innovative concept to the processed food industry. Also, it is an interesting contract to study since many of the unique aspects of a basis can be illustrated. From the citrus industry standpoint, concerns as to how this market has performed have been raised by both growers and processors. Growers and processors represent most of the commercial users of this contract and are most directly affected by basis changes (Dasse).

Given the above considerations, this paper explores empirically those variables contributing to the basis in FCOJ. These efforts are intended to both illustrate basis theory as it applies to a given commodity and to provide empirical reference for judging the economic performance of the orange concentrate contract. The basis model is developed in the first section followed by an estimation of the model for FCOJ. Finally, the last section gives the empirical contributions to the FCOJ basis and their economic interpretation.

Basis Theory

Distant futures exceed the spot price or nearby futures by the cost of storage and transformation, assuming both prices are for similar qualities. However, if nearby prices reflect a current shortage, some convenience yield exists for having at least a minimal

Ronald W. Ward is an associate professor, and Frank A. Dasse is an economist formerly with the Food and Resource Economics Department, University of Florida.

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stock, and this yield offsets at least part of the carrying cost (Kaldor, Working). If a current surplus exists, the market may pay a risk premium for holding stocks, thus adding to the basis spread. Storage costs, convenience yield, and risk premium have been used to develop the well-known theory of storage (Brennan, Weymar).

Weymar provides an empirical study of the supply of storage for cocoa where the spread between the futures and cash price is related to inventory levels. His model includes both a risk premium and a convenience yield that are related to inventory levels. Brennan's empirical evidence supports much of the early theory of convenience yield with his studies of the supply of storage. He shows that the spread between a futures and spot price can be explained in part by the net marginal outlay for storage. The net marginal outlay is defined as the marginal outlay for physical storage plus a marginal risk-aversion factor minus the marginal convenience yield on stocks. Gray further explores the evidence for a risk premium in spreads and concludes that the risk premium is of little use in partially explaining the spread.[1]

Each of these works adds to the basis theory yet fails to incorporate the uniqueness inherent in each contract market. This omission can distort the empirical results when a specific commodity market is being studied. The distortion in Brennan's model would be reflected in his derivation of the risk and convenience yield components of his model, since they are derived as the residual once the marginal storage cost is subtracted from the basis. In fact, the residual includes both theoretical components as well as contributing factors unique to a particular market.

As indicated above, the FCOJ market is a good example for illustrating the theory of storage in a basis model. A FCOJ basis for a contract t weeks from maturity is defined as[2]

$$(1) \qquad B_t = FP_t - (CP_t + TC_t),$$

where FP is futures prices per pounds of solids of bulk orange concentrate (dollars per pound solids) (Citrus Associates of the N.Y. Cotton Exchange), CP is raw fruit price delivered-in to the processor (dollars per pound solids) (Florida Canners Association), TC is cost of converting raw fruit into bulk concentrate (dollars per pound solids) (Florida Citrus Mutual), and t is weeks remaining in the life of a specific contract. The basis then reflects the cost of storage of bulk concentrate plus any interest on the initial cash outlay for CP and TC. Cost is defined as

$$(2) \qquad M_t = C_t + (e^{rt} - 1)(CP_t + TC_t),$$

where M is total storage and interest cost (dollars per pound solids), C is storage cost for t periods (dollars per pound solids) (Florida Citrus Mutual), r is equivalent weekly interest rate, and $(e^{rt} - 1)$ is an adjustment for calculating interest on the initial cash outlay. Subtracting the outlay from the basis yields the residual (BR_t) to the basis model, i.e., $BR_t = B_t - M_t$. BR then reflects the convenience yield, risk premium, and other variables specifically related to the concentrate market. Figure 1 provides historical weekly values of BR_t.

The FCOJ Basis Model

Basis models cannot be developed without a clear understanding of the chronology of the industry studied. Figure 2 indicates when events occur in the life of a particular FCOJ contract. The season officially begins 1 December, but the first crop estimate by the U.S. Department of Agriculture is released in October. The crop is susceptible to a freeze from December to mid-February, and the late crop is harvested by July.

During the latter months of the season there is considerable speculation about the next year's crop, and this information may be reflected in the contracts extended over these months. Finally, there is a continual need for

[1] The use of the term risk premium in the theory of futures trading has unfortunately taken a dual meaning in the literature. In the theory of storage, the carriers of stocks face an added risk from holding greater inventories and should be compensated for this risk through a risk premium (Cootner; Venkataramanan, p. 22). The theory of speculation includes a concept that hedgers pay to speculators a risk premium for bearing the risk of unanticipated price changes. While these concepts are not at odds they can lead to confusion in the literature (Venkataramanan, p. 52). Venkataramanan provides an extensive review of these concepts in his book, and Dusak gives a recent empirical study of risk premium relating to the theory of speculation.

[2] The basis is calculated with the derived cash price because an equivalent bulk price is not reported. A spot price could be derived using the FOB price and subtracting all cost related to putting the bulk concentrate into consumable packs. However, the FOB price does not respond as readily to weekly market conditions while the delivered-in price (CP) does. Hence, the method used in equation (1) proves to be more sensitive to current market conditions. A general basis model should reflect spatial differences due to delivery points. For FCOJ, however, all delivery points are in Florida, and there is little transportation difference among the delivery points.

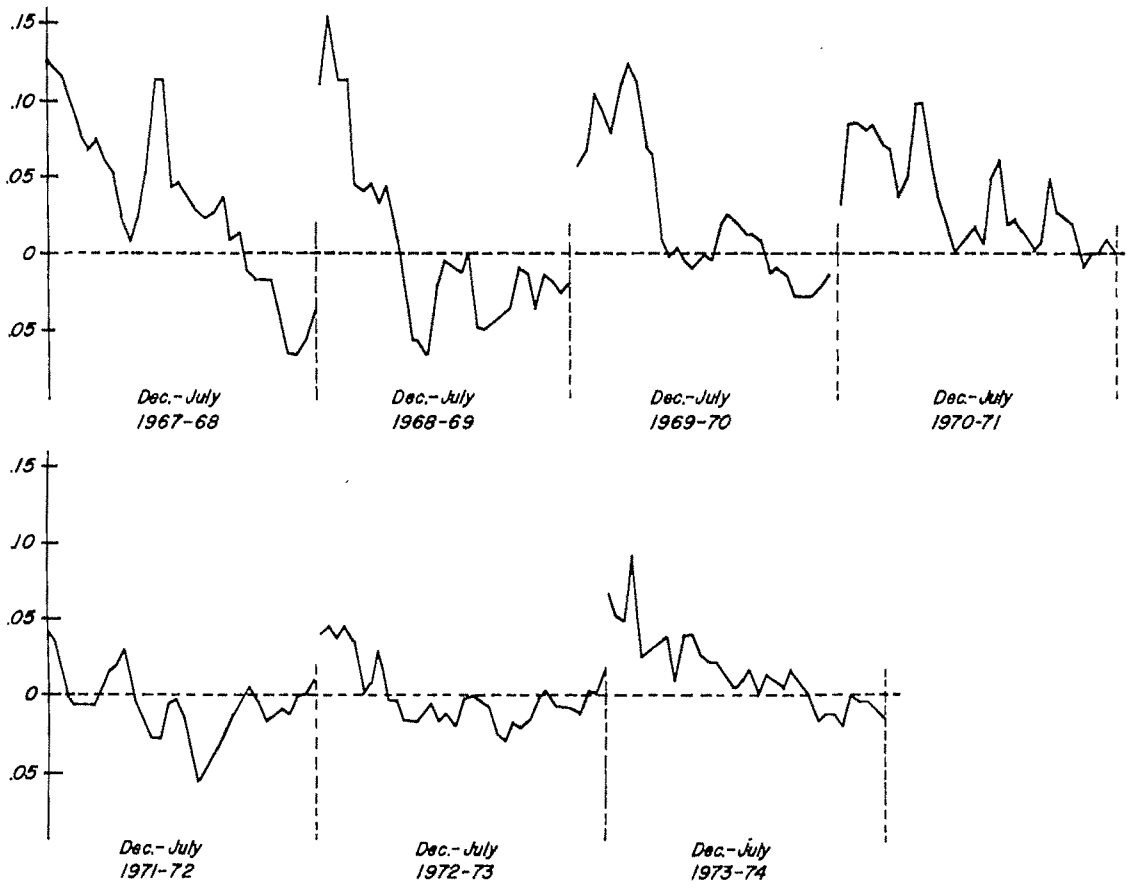


Figure 1. Basis residuals in the July FCOJ contract

storage since much of the fruit is processed into bulk concentrate and later converted to consumable packs (Ward and Dasse).

Recognizing these various events within the crop year, the July contract has been selected for studying the FCOJ basis model. July contracts extend over the complete harvesting period and should reflect a storage cost. Yet this contract is still far enough from the next season to not be greatly influenced by the new season's expected crop.

Six major variables are hypothesized to contribute to the FCOJ basis residual. A measure of risk premium, convenience yield, and market liquidity are general variables expected to be in all basis models, whereas a freeze bias, bias adjustments, and an actual freeze effect may be unique to the FCOJ market (Dasse).

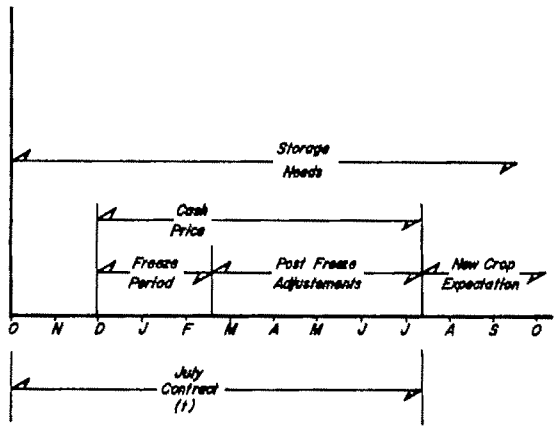


Figure 2. Chronology of citrus harvesting and marketing

Risk Premium

Price risk is inherent in the carrying of FCOJ inventories, and it is reasonable to expect the basis to reflect a risk premium as a facilitator for carrying stocks (Brennan, p. 50). Weymar explicitly notes that commodity holders can be induced to carry additional stocks given

an expectation of a return or risk premium for so doing. For FCOJ the risk from price changes increases as the level of projected stocks increase. If the level of stocks available (SA) projected for the season increases, then the level of price risk commercial traders face also increases. Traders may be induced to hold stocks during periods of high risk if the market pays a risk premium. However, as the contract approaches maturity, the level of risk exposure and hence the risk premium decline to zero.

Empirically, the risk premium (RP) for a contract at t weeks from maturity is defined as

$$RP_t = (SA_t)f(t), \tag{3}$$

where SA is total gallons or frozen concentrated orange juice for the season as estimated monthly by the USDA (millions of gallons), and $f(t)$ is some function of time from maturity (see table 1, footnote b). Changes in the risk premium are reflected in the basis with $\partial BR_t/\partial RP_t > 0$, while $\lim_{t\to 0} BR_t = 0$.

Convenience Yield

Convenience yield (CY) is attributed to being able to take advantage of a rise in demand and price without resorting to a revision of production schedules (Brennan, p. 54). When supplies are short, lack of adequate inventory results in lost sales and operational inefficiencies. Thus, for a firm to draw down inventories below adequate levels, the market must offer to pay for these costs. The market does this by bidding up prices in the near term in relation to distant prices. This allocative mechanism can lead to inverted markets where the convenience yield more than offsets storage cost and the nearby price exceeds the distant contract price.

For FCOJ the yield changes as inventories change. Define S_t as the ratio of inventories (I_t) to the norm ($\bar{I}_t$), then convenience yield changes with S_t such that $\partial CY_t/\partial S_t < 0$, $0 < S < 1$, and $\lim_{s\to 1} CY_t = 0$. When stocks are below the norm there is some positive yield in the basis. Yet as stocks increase up to the norm the yield approaches zero. Furthermore, as the contract nears maturity the market no longer reflects a convenience yield, i.e., $\lim_{t\to 0} CY = 0$, where t represents the weeks from contract maturity.

Using the above arguments with respect to S_t and t, an explicit function representing convenience yield is developed and used in the basis equation

$$CY_t = \begin{cases} \left(\frac{1}{S_t} - 1\right)f(t), & \text{if } 0 < S_t \leq 1, \\ 0, & \text{if } S_t > 1, \end{cases} \tag{4}$$

letting $S_t = I_t/\bar{I}_t$, where I_t is weeks of supplies of inventories on hand measured during t (Florida Canners Association), and $\bar{I}_t$ is average weeks of supplies on hand calculated for each week t and based on an average over the periods from 1958–59 to 1973–74 (Florida Canners Association).

Table 1. Estimates of the FCOJ Basis Residual Model

Equation	Constant	Risk Premium[b]	Convenience Yield	Market Liquidity	Freeze Bias		Freeze	Statistics
					FB	*FBA*		
(8a)[a]	−0.0266	0.3022E-05	−0.0029	0.4538E-04	0.3671	−0.2516	0.0155	$R^2 = 0.58$
	(−4.928)[c]	(1.263)	(−4.135)	(0.083)	(7.179)	(−4.742)	(7.064)	SSE = 0.23
								d = 0.52
(8b)	−0.0071[d]	0.1265E-05	−0.0021	−0.3022E-03	0.3259	−0.2140	0.0110	$R^2 = 0.35$
	(−2.580)	(0.339)	(−1.909)	(−0.955)	(4.147)	(−2.612)	(5.212)	SSE = 0.10
								d = 1.58

[a] Equation (8a) is based on $t^* = 21$ and $\rho = 0.65$. The equations are estimated with seven seasons, 1967–74, beginning the first week of December 1967 ($t = \max t$) and ending with the last trading week of July 1974 ($t = 0$). There are 225 degrees of freedom.

[b] Both risk premium and yield are some function of time into the contract life. Alternative $f(t)$ values (i.e., ln t, t^{-1}, and t) are estimated with the final model selected where $f(t) = t$.

[c] The t-statistics are given in the parenthesis. The variance-covariance matrix shows FB and FBA to be correlated. However, there is no other evidence of potential multicollinearity problems.

[d] The constant terms λ_0 in equation (8) follow from equation (8b), where $\lambda_0 = -0.0071/(1 - 0.65) = -0.0203$. Equation (8b) is estimated under the assumption $\rho = 0.65$.

Market Liquidity

The participation and level of activity by various traders may have a profound effect on the price discovery process. Ward's research indicates that too few speculators in the FCOJ market have a price-distorting effect during the closing contract months. This effect could differ, however, as various periods within the contract life are analyzed. An alternative to the speculative index developed by Ward is to use the ratio of trading volume to the changes in open interest for the contract within a given time period. This alternative is useful when data necessary for calculating a speculative index are not available.

The volume of trading (V) should exceed the absolute changes in open interest $|\Delta OI|$ enough to prevent price distortions from trader entry and exit into the futures market. A liquidity index is defined where both V and $|\Delta OI|$ are measured in contracts traded (Citrus Associates of the N.Y. Cotton Exchange):[3]

$$(5)\quad ML_t = \begin{cases} V_t/|\Delta OI|, & \text{if } |\Delta OI| \geq 1, \\ V_t, & \text{if } |\Delta OI| = 0. \end{cases}$$

The index lies in the range $1 \leq ML_t \leq V_t$ with the lower values suggesting possible liquidity problems. As the level of trading commitments increases, the volume of trading necessary in order to facilitate an orderly market is generally substantially greater than the volume just reflecting the changing open interest. Hence, the index is in the upper ranges in order to prevent possible price distortions.

Freeze Bias

The Florida orange industry is unique in that the production is concentrated geographically and can be severely influenced by a freeze. Empirically, a freeze potential leads to windfall gains to those speculative traders having established long positions in contracts extending over the freeze period. This potential for speculative gains attracts speculators into the FCOJ market, and in turn futures prices are generally bid up relative to the cash market. If the basis declines following the potential freeze period, then it is easy for short commercial traders to develop profitable hedging programs extending over the time of the freeze bias (Ward and Niles).

The actual price response to a freeze is hypothesized to be influenced by expected seasons availability (SA) of stocks. Large inventories lessen the price response if a freeze occurs, and this is reflected in the freeze bias.

There is some period t^* in the life of the contract where the potential for a freeze is over. At the start of each season shown in figure 1 the maximum value of t may differ slightly from one season to the next. Hence, max t is the maximum number of weeks from contract maturity and max $t - t^*$ is the maximum number of weeks the crop is subject to a freeze potential. When $t > t^*$ the market is expected to reflect a freeze bias. As t approaches t^* the bias is expected to decline and remain at zero when $t < t^*$. One alternative variable used to measure this bias is defined as

$$(6)\quad FB_t = \begin{cases} \ln\left(\dfrac{t - t^*}{\max t - t^*} + 1\right), & \text{if } t \geq t^*, \\ 0, & \text{if } t < t^*, \end{cases}$$

where $0 \leq t \leq \max t$ and $t^* < \max t$. As t declines, FB_t changes where $\mathrm{d}(FB_t)/\mathrm{d}t > 0$ and $\mathrm{d}^2(FB_t)/\mathrm{d}t^2 < 0$ for $t > t^*$. In equation (6) $t = \max t$ in the early part of the freeze potential period (see figure 2). When $t = t^*$, FB declines to ln 1 and remains at this value for the life of the contract. The value of t^* is not predetermined but must be established when the basis residual model is estimated.

As indicated earlier, the impact of a freeze potential is expected to be weighted by a measure of the expected seasons availability (SA). If SA is above the norm, then the freeze bias is reduced. Define a freeze bias adjustment (FBA) as

$$(7)\quad FBA_t = (FB_t)(NSA_t),$$

where $NSA = SA_t/\overline{SA}_t$, and $\overline{SA}$ is mean stocks calculated for each week t and based on an average over the 1967–74 seasons.

[3] The definition of ML in equation (5) is appealing in that it immediately suggests how much volume of trading occurs relative to the changes in contract commitments, i.e., if $ML_t = 3$, then trading activities exceed changes in commitments by a factor of three.

Based on equations (3) and (7), *SA* has a two-fold effect in the model. When *SA* is large the market may pay a risk premium for holding stocks. Yet large values of *SA* may dampen the potential windfall gains from a freeze as in equation (7).

Actual Freeze

While the FCOJ contract is hypothesized to reflect a freeze bias during the period $t > t^*$, the futures market may show additional reactions to the actual occurrence of a freeze. In contrast, the cash market may react somewhat slower, leading to upward but temporary adjustments in the basis.

A Florida freeze is generally measured in terms of the degrees below the 28 ° damaging freeze level. If *FZ* is defined as the average degrees below 28 ° during a week, then an increase in *FZ* leads to an increase in *BR*. In subsequent weeks, the cash price also responds to any freeze losses, and then the basis no longer reflects a freeze effect. Hence, in order to adequately explain the concentrate basis model, the unique effect of a freeze on the market must be incorporated into the model.

Empirical Results

The six basis variables have been defined over t with no reference to the data observed for different seasons shown in figure 1. In order to measure the model, each variable should be subscripted by i to denote the k seasons where $1 \leq i \leq k$. The i subscript has been dropped in the presentation for simplicity and should not cause any difficulty with the interpretation of the variables.

Incorporating the properly subscripted variables defined above to explain the basis residual gives

$$(8)\quad BR_{t(i)} = \lambda_0 + \lambda_1 RP_{t(i)} + \lambda_2 CY_{t(i)} + \lambda_3 ML_{t(i)} + \beta_1 FB_{t(i)} + \beta_2 FBA_{t(i)} + \beta_3 FZ_{t(i)} + \mu_{t(i)},$$

recalling from equations (1) and (2) that $BR_{t(i)} = B_{t(i)} - M_{t(i)}$. The λ_j coefficients relate to those theoretical variables common to all commodities, while the β_j's are unique to the FCOJ model. A priori, $\lambda_1 > 0$ since the basis pays a risk premium in accordance with the risk level. In contrast, $\lambda_2 < 0$ since the market reflects the economic value from having a level of stocks available to meet current market needs. The direction of price distortions due to lack of liquidity is not clear a priori, hence $\lambda_3 \gtrless 0$. The freeze bias is measured by positive increases in *BR*, thus, $\beta_1 > 0$. However, the adjustment to the freeze bias reduces the basis bias and $\beta_2 < 0$. Finally, an actual freeze increases the basis as reflected by $\beta_3 > 0$.

Two estimation problems are immediately evident in equation (8). First, the freeze bias variable (equation (6)) includes the constant t^*, which is unknown. Reference to figure 2 shows that generally $18 \leq t^* \leq 26$. Equation (8) is estimated using a maximum likelihood criteria where equation (8) is estimated over the range t^* and then the t^* is selected that gives the minimum sum of squared error (SSE).

Second, all variables are time series measured over k seasons. However, the series is discontinuous in that t does not span the full fifty-two weeks of each season. This gap invalidates the normal correction procedures for autocorrelation problems. The basic problem for this first-order autoregressive model is that the first error in season i is not related to last error in season $i - 1$ since there is a data gap between these two errors. If ρ is the autoregressive coefficient and $t' = \max t - t + 1$, then $\mu_{t'(i)} = \rho\mu_{t'-1(i)} + \epsilon_{t'(i)}$ if $t < \max t$, while $\mu_{1(i)} = \epsilon_{1(i)}$ when $t = \max t$. The autoregressive model is calculated using t' rather than t in order to conform better with standard notation. In the basis model t declines over the season while t' increases. Generalizing,

$$(9)\quad \mu_{t'(i)} = D\rho\mu_{t'-1(i)} + \epsilon_{t'(i)},$$

where $D = 1$ if $t < \max t$ and $D = 0$ if $t = \max t$. Using equation (9), it is relatively easy to show that ρ can be estimated by making the normal data transformation using $D\rho$.[4]

[4] The variance and covariance is calculated where

$$\operatorname{cov}(\mu_{t'(i)}\mu_{t'-s(i)}) = \begin{cases} \rho^s\sigma^2/(1-\rho), & \text{if } s \leq \max t, \\ 0, & \text{otherwise.} \end{cases}$$

Assuming that ρ and σ^2 are homogenous over seasons, then correction for serial correlation is used where the first observation of each seasons is weighted by $(1 - \rho^2)^{1/2}$ and the remaining observations weighted by $y - \rho y_{-1}$.

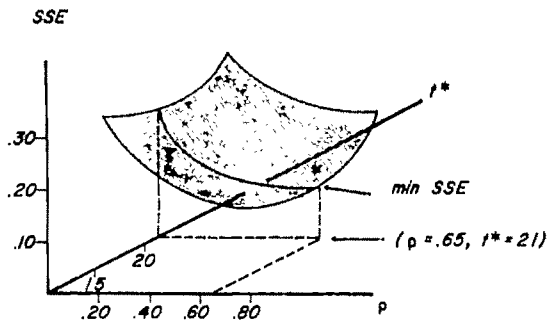


Figure 3. Error sums of squares over values of t^* and ρ

Equation (8) is estimated over the range of t^* and ρ giving the resulting SSE shown in figure 3. As evident in this figure, the freeze period is expected to end when the July contract is twenty-one weeks from maturity (i.e., $t^* = 21$). Similarly, the SSE reaches a minimum at $\rho = 0.65$ with little to no change occurring in the SSE for $\rho > 0.65$. The estimation results for $t^* = 21$ and for both $\rho = 0$ and $\rho = 0.65$ are given in table 1. The t-statistics are in parentheses and the seasonal subscript i is dropped for convenience.[5]

Efforts to establish empirically that the FCOJ market pays a risk premium have failed. There is no significant widening of the basis serving as a risk-rewarding inducement for holding inventories during high risk periods. The actual incidence of risk is a nonobservable variable and must be measured by proxy variables as in equation (3). Therefore, the evidence on risk premium must be interpreted with care since the conclusion can change according to how the actual risk premium variable is measured.

The basis residual model clearly reflects a significant convenience yield as evident in equation (8b) in table 1. The yield changes with both the stock level and the amount of trading time remaining in the contract (see equation (4)). For example, if stocks are 75% of the norm (i.e., $S_t = 0.75$) and if fifteen weeks remain in the contract life, then the contract reflects a yield of approximately 2.4¢ per pound solids. In this example, the basis would be 2.4¢ less than when supplies are normal.

Figure 4 shows various levels of yield over t and S_t. Although the convenience yield is present, it remains relatively small as long as $S_t > 0.75$. When $S_t < 0.75$, the yield increases substantially since

$$(10)\quad \frac{\partial BR_t}{\partial S_t} = \begin{cases} 0.0021t/S_t^2 > 0, & 0 < S_t < 1, \\ 0, & S_t \geq 1. \end{cases}$$

As S_t declines, the convenience yield increases and the basis residual declines and could ultimately result in a negative price spread. In such a case, the basis does not cover the full outlay developed in equation (2). Also, the presence of t in equation (10) further illustrates that the yield cannot lead to market inversions as the contract approaches maturity since $\lim_{t \to 0} \lambda_2 CY_t = 0$.

The July basis shows little response to the market liquidity variable developed in equation (5), suggesting that liquidity has not caused measurable distortions in the basis. Although the trading volume in FCOJ is small at times, it does not appear to have caused any abnormal basis adjustments over the July contract life. This analysis measures the basis over the life of one contract. In contrast, Ward's study uses a measure of the

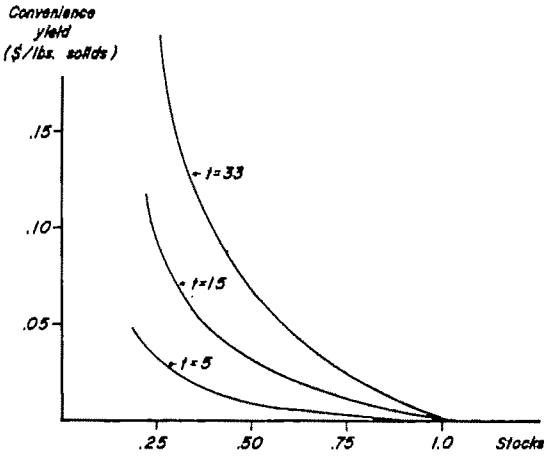


Figure 4. Convenience yield in the July FCOJ futures contract

[5] While the basis model is intended to deal primarily with the theory of storage and anticipatory effects, the relative large unexplained variation noted in equation (8b) can be troublesome to the trader. Much of the unexplained variation is related to the model's being estimated from weekly data. It is not abnormal to have lower R^2's for weekly versus longer time-series models. Furthermore, futures markets generally tend to respond to random information that does not immediately effect the cash market. Also, the futures price is selected at the weeks closing, and undoubtedly some variation is attributable to the price-selection criteria.

distortion based on a speculative index over all contracts during the closing period of the contracts.

Variables unique to the FCOJ basis model exhibit a pronounced effect on the basis residual, and an omission of these variables leads to a clear misspecification of the basis model. The variables *FB*, *FBA*, and *FZ* are unique to the concentrate market, yet they measure both the anticipatory effect from potential freezes and temporal differences in price adjustments. Although these phenomena are well known, they are seldom considered in any attempt to explain analytically the theory of storage (Brennan).

Considering first the anticipatory effect, a significant freeze bias is evident in equation (8b), table 1. The estimates from figure 3 indicated that the freeze period ends near the twenty-first week from contract maturity (mid-February). Hence, as long as $t > 21$, the results in equation (8b) show that the market includes a positive freeze bias where the basis exceeds the normal outlay from equation (2). The empirical measure of the freeze bias follows from equations (6), (7), and (8b), where

$$(11)\quad (\beta_1 + \beta_2 NBA_t)FB_t = (0.3259 - 0.2140 NSA_t)\ln\left(\frac{t - t^*}{\max t - t^*} + 1\right)$$

as long as $t > t^*$.

Equation (11) is illustrated in figure 5 where the darker curve represents the bias for a normal season (i.e., $NSA = 1.0$). Under these circumstances, the market generally reflects a freeze bias in the vicinity of 8¢ and then declines as the freeze period ends. In contrast, when the supplies are relatively small (i.e., $NSA < 1.0$) a freeze has a greater effect on the price since fewer stocks are available to offset any freeze loss. The market clearly reflects this potential in that the bias is above that shown for normal supply levels in figure 5. Similarly, if $NSA > 1.0$ there are more than normal inventories and a freeze potential does not have as great an effect on prices, as shown by the bias curve lying below the normal curve. For each level of *NSA* the bias remains relatively high through most of the freeze period and then declines rapidly as the period nears the end. This response is consistent with the situation where freezes are likely to occur any time within the freeze period until t is near t^*.

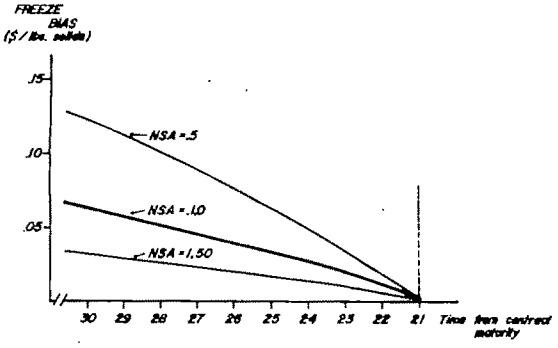


Figure 5. Freeze bias in the July FCOJ futures contract

The freeze bias can be expected to occur consistently even with extremely large crops. From equation (11), $NSA > 1.52$ before the freeze bias reduces to zero. However, the probability of *NSA* exceeding this level is extremely small.

The freeze bias in figure 5 provides a potential windfall to short hedgers. The basis widens at nearly the same time that many short-hedged positions are placed. The narrowing basis as the freeze period ends benefits the short hedger if the hedges are placed during those periods where the anticipatory effect is near a maximum. Hence correctly timing citrus hedging by both growers and processors to capitalize on the basis movements can lead to additional hedging gains (Niles and Ward). Also, an understanding of the crop size gives a trader some clue as to the potential basis gains that can be realized from short hedges.

While the freeze bias represents an anticipatory effect on the basis model, the actual freeze effect leads to price responses to factual information. The last variable in equation (8b) shows that the basis increases when a freeze occurs. Yet, after the freeze the basis again returns to the past freeze level assuming actual stocks are not changed. If temperatures drop to 24°, for example, $FZ = 4$, and the basis immediately widens by nearly 5¢. In succeeding weeks the basis adjusts back to the norm since both cash and futures markets then have time to assimilate information about the freeze.

The temporal basis response to varying freeze intensities illustrates to the long speculator that if his initial positions are placed at the proper time and price, then windfall gains are possible. However, if long positions

are placed after the market reflects the anticipatory effect of a freeze, then the potential speculative gains are greatly reduced. For the hedger, the freeze results are disturbing in that the futures side of a short-hedge position shows a loss. Yet, once the freeze information is assimilated into the cash market, the basis returns to the normal prefreeze level.

The closing period of the model is consistent with basis theory in that $\lim_{t \to 0} BR_t = \lambda_0 + \lambda_3 ML_t$ and C, RP, CY, FB, FBA, and $FZ = 0$. When the July contract ends most of the crop is harvested, and the freeze period is over. The closing spread shown in equation (2) approaches $\lambda_0 + \lambda_3 ML_t$. Since the liquidity parameter in the empirical model is insignificant, the closing basis approximates λ_0. In the perfect market the closing differential λ_0 represents the cost of delivery. However, the futures price generally reflects the lowest quality of product deliverable against the contract. Hence, λ_0 can be less than the cost of delivery. For the FCOJ July contract $\lambda_0 = -2.03¢$ per pound solids (see table 1, footnote d), which represents in part the quality differential between deliverable concentrate and concentrate normally used in commercial channels.

Conclusion

The basis model developed clearly supports both the theory of storage and establishes the necessity for measuring market bias. The results establish the credibility of the orange contract as a hedging tool and further illustrate certain basis patterns that can be used by the industry. Much of the basis theory cannot be clearly related to the practicing hedger nor is it necessary. Yet it is essential that traders using the market have confidence in its economic performance. Although the model does reflect the theory of storage, the actual basis residual model may differ substantially from the supply of storage models developed by Brennan and Weymar. Market bias can clearly cause deviations from the storage function. The cause of the bias must be recognized and remedied if needed. For the citrus contract, however, the freeze bias is a normal part of the anticipatory activity of the market and does not necessitate corrective action.

From a practical hedging standpoint the model provides useful guidelines for developing trading plans. In particular, the market does cover the cost of storage and exceeds this cost substantially during those periods where a positive market bias is evident. The model also suggests that traders must be prepared for basis shocks, especially during a freeze scare. The basis can widen and temporarily reduce basis gains from short hedging

From a government regulatory perspective, the empirical basis model supports the continuation of this contract if the market's performance is judged by conformity with theory. Likewise, the results have at least indirect implications for evaluating market manipulation on a large scale. Manipulative practices should visibly alter the basis performance relative to the basis theory and those unique factors measured in the basis residual model.

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The Effects of Property Taxes and Local Public Services upon Residential Property Values in Small Wisconsin Cities

Melville McMillan and Richard Carlson

Contrary to the results of similar studies in metropolitan areas, this investigation found no evidence that local property taxes and public expenditures were capitalized into the value of owner-occupied homes in small cities despite their considerable dependence upon the property tax. This does not imply that residents of small cities are insensitive to fiscal differences but rather is evidence of the more elastic supply of land for housing in nonmetropolitan communities.

Key words: nonmetropolitan centers, property tax, property values, tax capitalization.

Several papers report on studies of the effects of local property taxes and public expenditures on residential property values (King; Oates 1969, 1973; Orr; Pollackowski; Smith). Typically, these investigations are conducted in metropolitan areas and, although the situation, model specifications, and results vary, they usually, though not always (e.g., Wales and Wiens, Heinberg and Oates), present some evidence that property taxes and the benefits of public services are capitalized into local property values. The extent of capitalization in centers outside the metropolitan area is less certain. Hyman and Pasour, who studied 106 towns throughout North Carolina, found little evidence of capitalization in the nonmetropolitan context. These contradictory results can be attributed to differences in interjurisdictional mobility and elasticity of demand for residential land between metropolitan and nonmetropolitan regions.[1] However, because of the substantial state support to local government and the resulting low property tax rates in North Carolina, residential demand may be less sensitive to tax-expenditure differentials there. If capitalization exists, it is more likely to be evidenced where property taxes are a more important source of local finance and interjurisdictional differences are greater. In order to test whether significant capitalization exists in nonmetropolitan areas where, as is more typical, local governments must rely heavily on local sources of revenue, a study of taxes, services, and property values was undertaken in Wisconsin, where the average effective local property tax rate is two-and-one-half times that of North Carolina.[2]

The Model

The relation between local property taxes, public services, and residential property values was estimated using a linear regression model. Since factors other than taxes and the provision of government services influence property values, several other variables are included in the attempt to hold the attributes

Melville McMillan is an associate professor of economics at the University of Alberta, Canada, and Richard Carlson is a graduate research assistant in agricultural economics at the University of Wisconsin, Madison.

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[1] Capitalization is facilitated by high interjurisdictional mobility and the inelastic supply of residential property within each tax jurisdiction. Hyman and Pasour argue that metropolitan areas are characterized by greater mobility and that the long-run supply of housing is considerably more elastic in North Carolina than in a large SMSA (standard metropolitan statistical area).

[2] Pasour reports that the average owner-occupied home has a market value of $12,500 and a property tax bill of $155—a tax rate of $1.25 per $100 of market value. This contrasts with $3.25 per $100 market value in Wisconsin. A large part of this difference stems from the greater state contribution to school districts current operating costs in North Carolina (70%) than in Wisconsin (30%).

of the house and community constant. Two indicators of housing quality are utilized—the median number of rooms and the percentage of homes built since 1950.

Home values are affected by the character of the community, which is influenced by numerous and often unquantifiable variables (e.g., style, beauty and maintenance of homes, types and uses of neighboring properties, and extent of local organizations and community activities). Since these may be related to income, two income variables are employed as surrogates for community character—median family income and percentage of families with incomes below the official poverty level. Both variables also reflect political considerations. Median income is important as it commonly is assumed to characterize the median voter whose preferences are expected to dominate local public decisions (see Barlow). The percentage in poverty allows for the heterogenity of the community's composition and presumably preferences that may modify political decisions relative to those made in a more homogeneous unit.[3]

The percentage of homes owner-occupied may reflect community character, but, more importantly, it should account for any institutional and behavioral factors that prevent the same rate of capitalization from applying to both owner and renter-occupied homes. In addition, it should eliminate the bias caused by the dependent variable referring only to owner-occupied homes, while the income variables are characteristic of homeowners and renters together.[4]

The location of a city with respect to a larger metropolitan area is expected to affect residential property values. Proximity to a metropolitan area provides greater access to employment and recreational opportunities and additional retail and service outlets than are available to more isolated communities. To test the importance of proximity to metropolitan areas, a proxy variable, the population of the nearest standard metropolitan statistical area (SMSA) divided by the distance of the city to the SMSA's principal population center, was used. Although out of state, Minneapolis-St. Paul was the nearest population area in some cases.

Having controlled for the influence of various other factors affecting the value of owner-occupied homes, the significance of the fiscal variables can then be isolated. If capitalization occurs, the effective full-value local property tax rate as a measure of local tax cost is expected to be an important determinant of home values. This is the rate after adjustment of the nominal local rates for variations in assessment practices among jurisdictions (i.e., assessed value/market value) and for the tax credit paid by the state to those tax districts whose full-value rate exceeds one-half the statewide average. By incorporating these adjustments, this rate is comparable among jurisdictions as it reflects fairly accurately the tax cost per (as specified here) hundred dollars of property value. Some variations can still occur if the amount of real estate in each class (e.g., mercantile, manufacturing, and residential) and the assessment ratios applied to them vary among tax districts. In such cases the actual tax rate applying to homes in two tax districts could vary somewhat, although the composite effective full-value tax rate is the same in each jurisdiction.

Indexes of the output of local public services are more difficult to acquire. In spite of attempts to devise such indexes, researchers must often resort to using expenditures as a measure of output particularly when considering the aggregate public service bundle (Hirsch, chap. 7). This procedure has serious drawbacks if economies of scale exist, production technologies differ, and/or resources are not homogeneous. Despite these shortcomings, there is little choice but to accept expenditures as a proxy for public output while recognizing its deficiencies.

Two expenditure variables are used as output proxies: school operating expenditures per pupil and nonschool expenditures (excluding debt service) per capita. School expenditure is more likely to be significant since it represents the larger portion of total local expenditures, and people readily perceive those benefits school expenditures provide. Although school expenditures can sometimes serve as a proxy for the output of other local public services, it would be a poor

[3] Median family incomes may also reflect more traditional demand and supply effects. Higher income generally means larger expenditures on housing but may also imply higher costs of construction where incomes and wage rates are closely related.

[4] Oates uses the percentage in poverty as an adjustment to the assumed bias in the income variable with respect to home ownership. The percentage owner-occupied better serves the function here because the poor are more likely to own their own homes in small than in large urban centers.

index here as there is little relation between school and nonschool expenditures in these cities ($\rho = 0.076$). Including nonschool expenditures per capita accounts separately for benefits derived from nonschool services. Furthermore, it could correct for any bias in the estimation of the effect of the tax rate due to a positive association between nonschool expenditures and tax rates, although that is not a problem in this instance.

The empirical specification of the model is

$$(1) \qquad V = f(T, S, N, R, B, Y, L, \varnothing, U),$$

utilizing the notation defined in table 1. The model is tested using data for all incorporated Wisconsin cities meeting three conditions: (*a*) having a high school, (*b*) lying outside SMSA's, and (*c*) with a 2,500 to 25,000 person population. Sixty-five cities satisfy these criteria. The model is estimated using two-stage least squares (2SLS) regression. Ordinary least squares (OLS) estimates are expected to incorporate some simultaneous equation bias since the independent variables of concern (tax rate, school expenditure, and nonschool expenditure) depend to some extent upon the dependent variable—property value. If, as is shown to be the case here, the simultaneity is serious, the OLS estimates are not reliable. For comparative purposes, the Hyman and Pasour model and the Oates model are both estimated using the same data.

Empirical Results and Analysis

In order to remove the possibility of simultaneous equation bias, two-stage least squares procedures are used to predict values for the fiscal variables that, purged of their correlation with the error term, could be used to obtain an unbiased estimate. In the calculation of estimated values of the variables several additional variables believed to influence tax rates and public expenditures are included: (*a*) the percentage change in population from 1960 to 1970, (*b*) the assessed valuation of mercantile and manufacturing

Table 1. Variable Symbols, Units, and Expected Signs

Symbol	Variable Definition	Expected Sign
	Variables Appearing in Equation (I)	
Dependent variable		
V	Median value of owner-occupied homes, 1970[a] ($100)	
Fiscal variables		
T	Effective general property tax rate, 1970[b] ($/$100 market value)	−
S	School expenditures per pupil, 1969–70[c] ($)	+
N	Nonschool expenditures per capita, 1969–70[d] ($)	+
Nonfiscal variables		
R	Median number of rooms per owner-occupied unit, 1970[a]	+
B	Percentage of homes built since 1950, 1970[a]	+
Y	Median family income, 1970[e] ($1,000)	+
L	Percentage of families with income less than the 1970 poverty level, 1970[e]	−
$\varnothing$	Percentage of homes owner-occupied, 1970[a]	?
U	Population of nearest SMSA divided by distance of the city to the nearest principal population center in the SMSA (includes SMSA's in other states if closest), 1970[e,f] (1,000/miles)	+
	Additional Variables Appearing in Equations (II) and (III) (Hyman and Pasour and Oates Versions of the Model)	
D	Percentage change in number of owner-occupied units, 1960–70[a]	?
E	Local property taxes per capita, 1970[b] ($)	+
M	Distance to nearest principal city in nearest SMSA (includes SMSA's in other states if closest)[f] (miles)	−
P	Population, 1970[e] (1,000)	+

[a] Source: U.S. Dep. Commerce 1972.
[b] Source: Wisconsin, Department of Revenue.
[c] Source: Wisconsin, Department of Public Instruction.
[d] Source: Wisconsin, Department of Administration.
[e] Source: U.S. Dep. Commerce 1973.
[f] Source: Distance measured on a Rand-McNally and Co. map of Wisconsin.

property, (*c*) the average number of years of education of adults twenty-five years of age or over, and (*d*) the proportion of the total population attending either primary or secondary school. The Oates 1973 model also includes the proportion of homes owner-occupied in the first-stage estimate since this variable was not contained in his model's initial specification.[5]

A summary of the results obtained by 2SLS is shown in table 2. The specifications of the model chosen for this study are equations (Ia) and (Ib). (The Hyman and Pasour and the Oates 1973 versions are equations (II) and (III), respectively.) Of the nonfiscal variables in equation (Ia), the coefficients of the proximity to SMSA measure, the percentage of homes owner-occupied, and the percentage of new homes all display some degree of significance. The assumed signs appear in the results. The percentage of owner-occupied units, which does not have a sign specified in the model, has a negative sign, indicating that owner-occupied homes have a higher median value where renter-occupied homes are a larger portion of total units. This probably results partly because renting is more important in larger and growing cities where home values tend to be higher.

The coefficients of the median number of rooms, median family income, and the percentage of families with income less than the poverty level are all insignificant. However, a substantial amount of collinearity exists between income and the percentage of poor, homes built since 1950, and the tax variable ($\rho = -0.808$, 0.643, and 0.504, respectively). Also, the median number of rooms is somewhat correlated with several of the other measures, but its low coefficient is most likely the result of there being little spread in the data (5.3 to 6.2 rooms). Although including all these variables is justifiable, especially since we are not concerned principally with estimating the coefficients of the nonfiscal variables, for practical purposes equation (Ib) is also presented, which is like equation (Ia) except that the variables median income and median number of rooms are deleted. The only effect is to increase the *t*-value of some coefficients, most notably that of the percentage of homes owner-occupied.

In neither equation are the coefficients of the fiscal variables significant. This indicates that in these communities the benefits and

[5] In the strict sense this is not a 2SLS model but a form of instrumental variables. A true 2SLS model uses all the predetermined variables from a completely specified system of equations in the first-stage estimates. As a full model has not been specified here, our selection of additional predetermined variables may be incomplete, in which case the method used is instrumental variables. However, as the procedure adopted here parallels that referred to as 2SLS by others writing on this topic (e.g., Oates 1969, 1973), in order to avoid confusion in relating to their work we continue the inprecise convention of calling this technique 2SLS, while recognizing that it may in fact be instrumental variables depending upon the completeness of the selection of the predetermined variables.

Table 2. Summary of Two-Stage Least Squares Regression Results

Equation (Ia)	$V = 225.5 - 26.65T^* + 0.0862S^* - 0.0899N^* + 0.695R + 1.443B + 0.560Y$ (0.95) (−0.80) (0.45) (−0.49) (0.04) (3.21) (0.10) $- 1.055L + 0.2555U - 1.310\emptyset$ (−0.81) (1.86) (−1.75)	$R^2 = 0.83$
Equation (Ib)	$V = 239.3 - 28.45T^* + 0.0916S^* - 0.1016N^* + 1.438B - 1.2224L + 0.2491U$ (1.73) (−1.63) (1.10) (−0.74) (3.39) (−1.42) (1.98) $- 1.3159\emptyset$ (−3.06)	$R^2 = 0.82$
Equation (II)	$V = 215.6 - 13.13T^* - 0.0313E^* - 9.717R + 14.13Y + 0.4684U - 1.555\emptyset$ (1.23) (−0.41) (−0.30) (−1.01) (3.08) (3.31) (−4.24) $- 0.0953P + 0.0950D$ (−0.18) (0.48)	$R^2 = 0.74$
Equation (IIIa)	$V = -1589.5 + 85.66(\ln T)^* + 262.6(\ln S)^* - 19.62(\ln N)^* - 23.24R + 2.077B$ (−2.05) (0.61) (2.02) (−0.64) (−0.77) (2.39) $+ 8.500Y + 1.018L + 0.961(\ln M)$ (0.81) (0.44) (0.08)	$R^2 = -0.08$
Equation (IIIb)	$V = -271.9 - 47.11(\ln T)^* + 74.01(\ln S)^* - 5.44(\ln N)^* + 4.03R + 1.810B$ (0.26) (−0.40) (0.48) (−0.32) (0.17) (4.25) $+ 2.177Y - 0.733L + 1.353(\ln M) - 1.173\emptyset$ (0.33) (−0.44) (0.25) (−1.32)	$R^2 = 0.80$

Note: Numbers in parentheses are the *t*-statistics. The asterisk indicates an endogenous variable.

costs of public services have not been capitalized into the value of owner-occupied homes. This result is substantiated by the fact that the nonfiscal variables alone account for 80% of the variation, while the fiscal variables, when regressed against property values, explain very little.

To check the results two alternative specifications of the model are estimated. Equation (II) is the Hyman-Pasour model fitted to Wisconsin data. Different nonfiscal variables are the population of the community and the percentage change in the number of owner-occupied homes for 1960 to 1970. Neither variable has a significant coefficient. The coefficient of population may be insignificant because both costs and benefits of living in urban centers increase with population. Since they were unable to obtain census data on the percentage of homes built since 1950 at the time of their study, Hyman and Pasour used the change in the number of owner-occupied homes from 1960 to 1970 as a second-best measure of the average age of homes. Correlation between these two variables ($\rho = 0.263$) indicates that, for Wisconsin data at least, it is not a particularly good substitute.

The coefficients of certain other nonfiscal variables are significant. Both the percentage of homes owner-occupied and the measure of proximity to metropolitan centers have significant coefficients. In the absence of the poverty measure, the coefficient of median family income is significant.

After testing several alternative measures of government output, Hyman and Pasour let the data choose the variable to be included in their final equation, local property taxes per capita, although it is further removed than expenditures from the benefits of public services. Neither this coefficient nor that of the other fiscal variable, tax rate, are significantly different from zero.

The revised Oates 1973 model fitted to the Wisconsin data (equation (IIIa), table 2) provides a second alternative specification. Oates assumed that the tax rate, the spending variables, and the distance to the metropolitan center would have an exponential relation and, therefore, used a logarithmic transformation of these four variables, which did improve explanatory power in his study. The use of the logarithmic form on these data does not appear justified. Because individual family and home data are aggregated into a single observation for each community and the level of the fiscal variables does not differ by much due to institutional rigidities, the spread of the data is not great.[6] Thus, over the range of data likely to be encountered, logarithmic and linear functions will not differ substantially. It is only in this form of the model that a fiscal variable displays a significant coefficient, i.e., nonschool expenditures per capita. But the R^2 in this case is only -0.08. Although R^2 in 2SLS models usually appears between zero and one, zero or negative values are possible when residuals are correctly calculated and need not indicate that the results should be discarded (Tomek). Since the other two models contain the additional variable, percentage of all units owner-occupied, this variable is added to Oates's original specification and estimated as shown by equation (IIIb) of table 2. With the inclusion of this variable, R^2 increases to 0.80, but the coefficient of school expenditure per capita becomes insignificant.[7] The only variable to have a significant coefficient in both forms of the Oates model is the percentage of homes built since 1950. While satisfactory in his metropolitan context, the use of distance alone rather than population divided by distance does not perform well as a measure of accessibility in this nonmetropolitan situation.

Implications

Although equation (I) is preferred theoretically and explains better than the other two models or their variations, in general the performance of the three models is consistent and largely as expected. Overall, certain nonfiscal factors (e.g., the percentage of homes built since 1950, proximity to metropolitan areas, and the percentage owner-occupied) appear to influence the value of owner-occupied homes in small urban centers, but fiscal factors apparently are unimportant.[8] As

[6] While tax rates range between 26.15 and 40.23 mills, they have a standard deviation of 3.278 about a mean of 32.45 mills. School expenditures vary from $513 to $836 per pupil with a standard deviation of $70.53 about the mean of $656.02.

[7] The fit and significance of coefficients of equations (Ia) and (Ib) are also sensitive to the inclusion of owner-occupancy, although that of equation (II) is less so, apparently because income and population substitute is part of that variable.

[8] In contrast, OLS estimates yield significant coefficients for the tax rate and school expenditure variables that are consistent with full capitalization if the rate of interest is 5% and property life is forty-five years. For example, increasing property taxes by $100 to finance an additional $100 of school expenditure has

property taxes in Wisconsin are substantial, the fiscal variables are not irrelevant because of relatively small local contributions but rather because of the structure of the small urban center housing market.

While the short-run supply of improvements is likely to be quite inelastic and the price of existing units sensitive to tax rates, the long-run supply of structures to residential housing is generally believed to be quite elastic (Muth). As a result of the supply of capital to housing being elastic, increased property taxes must either be shifted forward to consumers through higher prices or backwards to land as the tax is capitalized into lower property values. The direction and extent of the shifting (and capitalization) depends on the relative elasticities of supply and demand. On the supply side it is reasonable to expect that in most instances the long-run supply of land for development is elastic (McMillan). An exception occurs within major urban areas where, other than at the urban fringe, the amount of land available for development in each jurisdiction is relatively small and its alternative uses limited. Consequently, the supply of housing is expected to be more inelastic in jurisdictions within metropolitan areas where the supply of developable land is more restricted and the value of the land to residential improvements is greater than in small urban centers.[9]

The metropolitan environment also affords greater opportunity for home buyers to react to differences in property tax rates and public services among jurisdictions. Because of the multiplicity of municipalities within close proximity to one another, individuals are not restricted by time and distance to living and working in the same jurisdiction but are able to select among municipalities on the basis of tastes and preferences. That consumers of housing respond to local fiscal considerations (outputs and costs) in selecting their community of residence was postulated by Tiebout, and Oates's work is considered evidence that account is taken of fiscal differentials as people compete for the preferred sites in the metropolitan area.[10]

Conversely, in nonmetropolitan areas, location alternatives are more restricted. The location of employment opportunities are much more influential in determining an individual's place of residence; unlike the Tiebout model, individual's incomes are to some extent location specific. Within the vicinity bounded by travel costs, the choices may be quite limited. In many rural localities, if one wishes the benefits of basic urban services, they may be available from only one municipality. As a result, the individual's ability to express satisfaction with the public sector, or even to realize the range of alternatives available, is constrained, making remote the likelihood that differentials in the quality of service, particularly moderate ones, will be reflected in local property values.[11]

That the demand for housing is less elastic and the supply more elastic in small urban than metropolitan areas is consistent with capitalization of taxes and public expenditures being evidenced only in the latter. The failure of intercity fiscal differentials to be reflected in property values in a situation where local taxes are substantial is evidence that the supply of residences in nonmetropolitan urban centers is elastic. Of relative elasticities of demand less can be said as noncapitalization does not indicate that the Tiebout process does not operate to some degree among nonmetropolitan cities, although it is not expected to be as pronounced as within metropolitan areas. People may still prefer and seek out those communities offering greater net fiscal benefits, but because of the high elasticity of housing supply the impact is more upon those communities' growth rates than their property values. Because the number of sites in a specific jurisdiction may be limited in metropolitan areas, the impact upon property values is greater.

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a net effect of reducing the median home value by $811 (i.e., $1,296 − $485). This comparison of OLS and 2SLS results differs substantially from that of Oates who observed no significant difference between the two methods and that of Hyman and Pasour who, due to the lack of variation in the predicted value of the effective property tax rate, found 2SLS unsatisfactory. Because of the importance of property taxes in Wisconsin, 2SLS procedures are believed necessary to account for the relationships between property values and the fiscal variables, which lead here to dismissing the OLS results as spurious.

[9] Hyman and Pasour also believe that more restricted entry to the construction industry in metropolitan areas makes supply more inelastic there.

[10] Oates's results are based on a cross-sectional study of fifty-three residential communities in northeastern New Jersey, all located within the New York metropolitan region (1969).

[11] Instead, rural communities displaying superior public sector performance may be characterized by more rapid growth rather than by higher property values. Weaver and McMillan found that during the 1960s manufacturing employment grew most rapidly in those cities believed to offer a higher quality of public service. Higher local tax rates detracted from local growth but had a very small effect.

In a time when a reduction in the dependence of local school finance upon the property tax is sought, a major implication of the results of this study is that decreasing property taxes will likely not lead to sizable capital gains for owners of residential property in small cities. Some increase could arise due to capitalization in markets where the supply of housing is less elastic, depending upon the degree of substitutability of property among the elastic and inelastic markets. In contrast, evidence from other studies suggests that the owners of farm real estate (Pasour) and metropolitan residences can expect their property values to appreciate if property taxes were reduced.

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A Quantitative Investigation of a Political Economy—The Israeli Dairy Program

Pinhas Zusman and Amotz Amiad

The formation of economic policy reflects the underlying economic and political structure. A game theoretic approach is employed in formulating the political structure, which is then combined with the economic structure to yield a model of a political economy. The parameters of the model are estimable from observed behavior. A model of the Israeli dairy program is constructed and estimated. The power relations and the structure of the conflict among interest groups are investigated.

Key words: dairy program, economic policy, interest groups, Israel, political power.

A political economy, as conceived in the present study, is a system of economic and political relations that together determine the values of the endogenous economic variables as well as those of the policy instruments. In dealing with such systems, not only are we interested in the question, "Given the values of the policy instruments, how are values of the endogenous variables determined?" but also in the question, "How are the values of the policy instruments determined?"

In attempting to answer the last question, one could adopt Tinbergen's normative approach and hypothesize an optimizing behavior on the part of policy makers (1956). The political-economic structure will then consist of the economic structure, a policy objective function, and various constraints on the policy instruments. Indeed, several successful attempts at estimating the policy objective function have been reported (Friedlander).

An alternative, and more realistic, approach was adopted by Rausser and Freebairn. They recognized the bargaining nature of the political process but claimed that the outcome of the process can be predicted by maximizing an appropriate "policy preference function." Their main contribution is in recognizing the role of pressure groups in the political process and in the corresponding formulation of the policy preference function in terms of the groups' objectives. However, Rausser and Freebairn did not provide a formal structure of political economy, and it is not clear why a policy preference function should exist at all. Furthermore, even if its existence is admitted, the problem of its interpretation is yet to be settled.

A formal structure of a political economy was proposed by Zusman. In his model the political power of the various interest groups is explicitly recognized, and the resulting political economic equilibrium is a solution to the corresponding bargaining game. The formulation also allows for the estimation of political power parameters, and it is employed in investigating the Israeli dairy program. However, while Zusman's paper took the interest groups' objective functions as given, the present analysis focuses on their identification and measurement and also seeks answers to the questions, "What is the structure of the underlying conflict, and does the prevailing power structure allow for further policy improvements?"

The Conceptual Structure of a Political Economy

The structure of a political economy consists of the following components: (*a*) the economic structural equations; (*b*) the set X_0 of feasible policy instruments; (*c*) the policy

Pinhas Zusman is a research economist at the Development Research Center of the International Bank for Reconstruction and Development on leave from the Hebrew University of Jerusalem, and Amotz Amiad is a lecturer at the Hebrew University of Jerusalem.

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The conditions assuring the existence and uniqueness of a solution to the problem thus depend on the set of constraints in the programming problem, equation (2). Intuitively, the conditions are rather mild—the efficiency frontier determined by $G(x_0) \geq 0$ and $u(x_0)$ should be continuous, and the tangent plane to it should have positive coefficient everywhere. There should exist possible trade-off relationships between the objective functions of every pair of interest groups.

The solution of the programming problem for $n = 1$ is presented graphically in fig 1. In the application below, a modified gradient method is used to obtain the desired values.[4]

[4] In addition to its usefulness in analyzing behavioral systems, programming problem, equation (2), can be instrumental in developing possible improvements in existing policies. Since the gains are distributed equally among all interest groups, the proposed political changes are more likely to be accepted. The solution procedure, developed by the present authors, consists of a sequence of restricted steps. In each step the objective function (V) is increased by solving a local linear programming problem obtained by an appropriate linearization of the system. The solution in each step serves as the linearization base of the next step. The sequence commences at the observed solution (x_0') and leads to x_0^*, where the conditions for maximum V are met. A description of the solution algorithm is available from the authors.

The Israeli Dairy Program

Government intervention in the Israeli dairy market during the last two decades has been significant and consistent. Imports of dairy products were limited to the bare minimum and were subjected to a sizable duty. Farm prices for raw milk were guaranteed at rather high levels, so that production of raw milk had to be controlled through a system of production allotments. Consumer prices were set at low levels, which failed to cover processors' total costs (raw material plus processing costs), involving the government in high subsidies. A peculiar feature of the subsidy program was the differential support to the various dairy products. Consumer prices of fluid milk were set at high levels, so that only a small subsidy was required, whereas other dairy products enjoyed a heavy subsidy and low consumer prices. This mode of government intervention persisted throughout the entire period, surviving several heated debates concerning its desirability.

The rest of this study is devoted to the exploration of the determinants of the political-economic equilibrium in the Israeli dairy

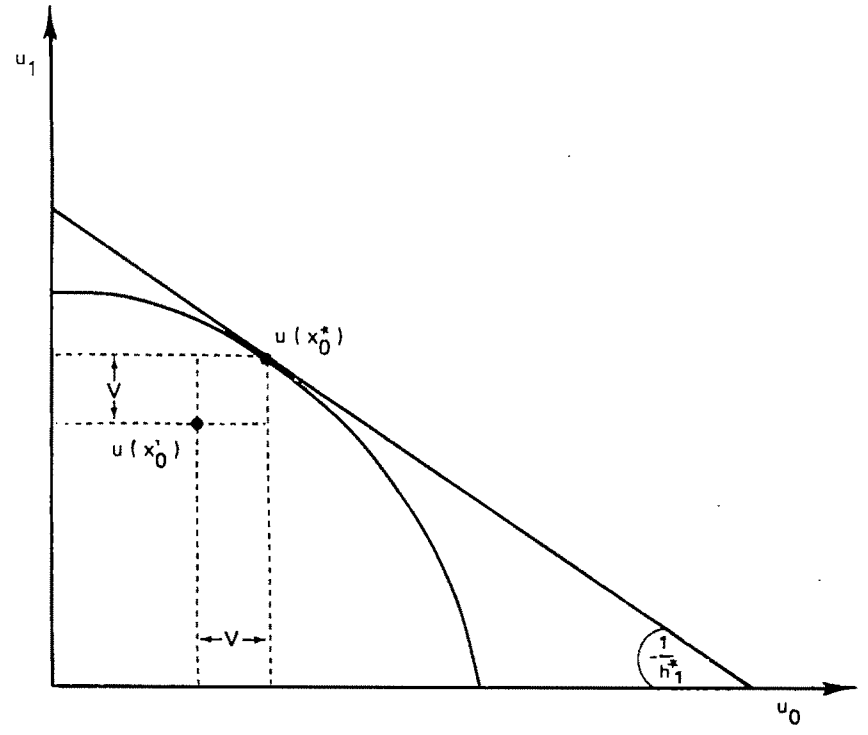


Figure 1. The estimation of a theoretical solution in a political-economic system with two players

market. To this end the model presented in the preceding sections is applied to conditions prevailing in 1968–69 (October 1968–September 1969).

The Economic Structure of the Israeli Dairy Market

To simplify the analysis, all dairy products were aggregated into two main groups: fluid milk and other dairy products. The estimated demand functions for 1968–69 were

$$q_f = 188{,}348\ P_f^{-0.05}, \tag{3}$$

and

$$q_p = 778{,}123.7\ I^{0.773} P_p^{-1.21}, \tag{4}$$

where q_f is annual demand for fluid milk (expressed in kiloliters raw milk equivalents); q_p is annual demand for other dairy products (expressed in kiloliters raw milk equivalents); I is total per capital consumption expenditures (IL [lira] per capita); P_f is consumer price of fluid milk (IL per kiloliter raw milk); P_p is consumer price of other dairy products (IL per kiloliter raw milk). The demand equations were derived by fitting demand elasticities estimated by Rimland to 1968–69 prices, quantities, and per capita consumption expenditures (Israel Central Bureau of Statistics).

Worth noting is the low price elasticity of demand for fluid milk (−0.05) as compared to that of other dairy products (−0.121). As will be asserted subsequently, the differential subsidy policy stems largely from this difference in the price elasticities.

Total domestic production of raw milk is an important policy instrument. Since fluid milk cannot be imported, domestic production of raw milk is first allocated to this utilization, the remainder is diverted to other dairy products. Excess domestic demand for dairy products is ordinarily met by imports of powdered milk and butter. These relations are represented by the following balance equations:

$$Q = q_f + q_i \tag{5}$$

and

$$q_{pm} = q_p - q_i, \tag{6}$$

where Q is total domestic production of raw milk (kiloliters); q_i is utilization of domestically produced raw milk for other dairy products (kiloliters); and q_{pm} is imports of powdered milk and butter (expressed in kiloliters of raw milk equivalents).

Two politically and economically meaningful sectors of dairy farms were distinguished: large cooperative farms (kibbutz farms) and family farms (moshav farms). The two sectors apply different production methods and also constitute distinct political organizations. The intersectoral allocation of total milk production is an important policy instrument. We thus have

$$Q_1 = kQ, \tag{7}$$

$$Q_2 = (1 - k)Q, \tag{8}$$

$$C_1 = 378.5Q_1, \tag{9}$$

and

$$C_2 = 418.8Q_2, \tag{10}$$

where Q_1 is production of raw milk by kibbutz farms (kiloliters); Q_2 is production of raw milk by moshav farms (kiloliters); k is share of kibbutz farm in total domestic production of raw milk ($0 \leq k \leq 1$); C_1 is total cost of milk production by kibbutz farms (IL); and C_2 is total cost of milk production by moshav farms (IL). Cost figures were obtained from the Institute of Farm Income Research. Owing to economies of scale, the cost of milk production in moshav farms exceeds that of the kibbutz. The constant average cost formulation was adopted in order to facilitate the analysis.

Consumer prices are set by the government at relatively low levels. Processors' returns from sales are, therefore, supplemented by a handsome government subsidy. About 90% of the raw milk is processed in dairy plants owned by farmers' cooperatives. Farm prices of raw milk are determined by total value of sales plus subsidy net of processing cost as follows:

$$C_p = 66.0q_f + 219.0q_i, \tag{11}$$

$$R = P_f q_f + P_p q_i + SQ, \tag{12}$$

and

$$P_m = \frac{R - C_p}{Q}, \tag{13}$$

where C_p is total processing cost (IL); R is total revenue, including subsidy receipts (IL); S is average subsidy (IL per kiloliter raw milk); and P_m is farm price for raw milk (IL per kiloliter raw milk). Equation (11) relates the total cost of processing to the quantities of the various dairy products.[5] Equation (12) relates total revenues to sales and subsidy receipts, while equation (13) is a definitional relation.

The endogenous variables are q_f, q_p, q_i, q_{pm}, Q_1, Q_2, C_1, C_2, C_p, R, and P_m, eleven variables in all. Their values are determined by equations (3) through (13). The policy instruments are P_f, P_p, Q, k, and S. How are values of the policy instruments determined? To answer this, one must investigate the political relations in the system.

The Political Structure of the Israeli Dairy Market

Three interest groups were distinguished in the analysis: kibbutz farms, moshav farms, and consumers. Both the kibbutz and the moshav groups are well organized and influential. They form powerful blocks in the political parties participating in the coalition government, and their representation in the legislative and executive branches of government exceeds substantially their share in the population. They also control all agricultural marketing boards and man important positions in the Ministry of Agriculture. Moshav farmers are more numerous than kibbutz members but are somewhat less active politically.

The objective functions of the farmers' groups were first identified with their net income, i.e.,

$$u_1 = P_m Q_1 - C_1 \tag{14}$$

and

$$u_2 = P_m Q_2 - C_2. \tag{15}$$

Consumers, in general, constitute a diffused political entity. Their awareness and sensitivity to changes in the policy parameters are low and apart from a very weak Consumers Council lack any formal organization. The Israeli press may at times reflect consumers' attitudes very effectively but is very rarely interested in the dairy market as such. For a variety of reasons, the general trade union organization, the Histadrut, has undertaken to represent consumers' interests. Since the Histadrut is politically powerful, consumers' power has thus been reinforced.

The objective function of the consumers' group has been identified with the consumer surplus:

$$u_3 = 198{,}261\,(P_f^{*0.95} - P_f^{0.95}) - 3{,}705{,}348\,I^{0.773}(P_p^{*-0.21} - P_p^{-0.21}), \tag{16}$$

where $P_f^* = P_p^* = 1{,}000$ are arbitrary high values of P_f and P_p, respectively.[6]

Ultimate policy decisions with respect to the dairy program are made by the Minister of Agriculture and the Minister of Treasury. It is rather difficult to determine the objective function of this policy-making group. Nevertheless, given the dominant position of the treasury in the Israeli government, it is reasonable to assume that considerations related to tax collection or alternative claims on public funds are of primary importance. The objective function of the policy makers is identified with the net cost of the dairy program, which is obtained by deducting the proceeds from duties levied on imports of dairy products from the total subsidy expenditures. Thus,

$$u_0 = -SQ + 60.4q_{pm}. \tag{17}$$

Besides the ordinary nonnegativity constraints, which all prices and quantities must obey, two additional constraints have been added. The first is technical: fluid milk cannot be imported, i.e.,

$$q_p - q_{pm} \geq 0. \tag{18}$$

The second is definitional: the shares of the kibbutz farms in total production cannot exceed 100%:

$$0 \leq k \leq 1. \tag{19}$$

An important constraint is implicitly as-

[5] Processing cost of fluid milk is based on data obtained from Koisch and Zukerman. The corresponding cost for other dairy products was obtained by applying equations (11), (12), and (13) to 1968–69 figures.

[6] In the present formulation the exact values of P_f^* and P_p^* are of no concern, since they affect only the constant term in the maximand W. This is because the power coefficients were assumed to be constant. In the more general case, where the power coefficients vary, the values of P_f^* and P_p^* are important and should not be selected arbitrarily.

sumed: no direct income transfers are permitted.

The Political-Economic Equilibrium in the Israeli Dairy Market

The solution procedure was first employed in analyzing the political-economic relations represented by equations (3) through (19). The results of the analysis, i.e., the theoretical values of the policy instruments, the power coefficients (H_i^*), and some endogenous variables, are given in column (3), table 1, where they are compared to the observed values of the respective variables (column (2)).

At first glance, the results were very discouraging. Clearly, there is a sizable discrepancy between the observed and calculated values. The model does very poorly in explaining actual behavior. Why did politicians stick to such an inefficient economic policy? As the analysis suggests, changing the prevailing policy could raise the objective function of every interest group by some IL11,786,450, a significant improvement. It is unlikely that this behavior be attributed to ignorance. In fact, for many years it has been argued by some government officials and economists alike that the Israeli milk program is no good, Israel is producing too much milk and importing too little, the subsidy is excessive, and production should be reallocated among farmers in a more efficient way. These arguments were opposed vehemently by farm leaders, in spite of the fact that producers could share the benefits accruing from a revised policy. Consequently, no such change ever took place. The ignorance hypothesis was, therefore, rejected.

An alternative hypothesis had to do with the producers' objectives. In the political process, farmers are represented by their leaders. Farm leaders' goals do not necessarily coincide with those of the farmers. While each individual producer may be interested above all in his own net income, the leader's objectives are more complex. In particular, he must accommodate his constituency in some measure. From the point of view of the individual producer, the milk price is given, but his production quota is allocated to him through his representatives. Hence, farm leaders are under constant pressure to raise production quotas; the higher the milk prices, the greater the pressures. Therefore, it seems reasonable to regard production quotas as another target variable of the farm sectors. Equations (14) and (15) were, therefore, replaced by

$$u_1 = \left(\frac{Q_1}{Q_1'}\right)^{\beta} [P_m Q_1 - C_1], \tag{20}$$

and

$$u_2 = \left(\frac{Q_2}{Q_2'}\right)^{\beta} [P_m Q_2 - C_2], \tag{21}$$

where Q_1' and Q_2' are the observed 1968–69 values of Q_1 and Q_2, respectively, and β is an unknown nonnegative parameter reflecting the importance that farm leaders attribute to the production quota. The higher the value of β, the more desirable is a high quota relative to its 1968–69 value. The calculated equilib-

Table 1. Actual and Equilibrium Values of Economic Variables and Power Coefficients, 1968–69

Variables	Actual Values	Calculated Values		
		$\beta = 0$	$\beta = 2$	$\beta = 3$
Consumer price for fluid milk (P_f)	495.4	522.2	581.3	587.5
Consumer price for other dairy products (P_p)	480.4	422.2	429.5	429.6
Total domestic production (Q)	366,713	137,742	286,394	325,114
Domestic production of other dairy products (q_i)	228,606	0	149,387	188,180
Import of dairy products (q_{pm})	18,000	288,699	133,456	94,532
Share of kibbutz farms in total production (k)	0.459	0.541	0.495	0.480
Subsidy rate (S)	118.9	227.7	147.2	131.2
Farm price of raw milk (P_{m1})	443.6	683.9	503.5	472.8
Power coefficient, kibbutz farms (H^*_1)	—	0.936	1.134	0.906
Power coefficient, moshav farms (H^*_2)	—	1.080	2.241	2.039
Power coefficient, consumers (H^*_3)	—	0.996	0.973	0.975
Gain in objective function $u_i(x^*_0) - u_i(x'_0)$	0	11,786,450	1,605,881	740,674

rium values corresponding to $\beta = 2$ and $\beta = 3$ are presented in columns (4) and (5), table 1.

Although it is not entirely satisfactory, the explanatory power of the model is raised considerably by the inclusion of production quotas as target variables of the farm sectors. Thus, with $\beta = 3$, the theoretical level of domestic production is much closer to the actual one, an outcome attained through import substitution. The theoretical farm price, subsidy rate, and production allotments are also more in line with the observed values. However, the theoretical consumer prices differ substantially from the actual prices. Furthermore, the predictive power of the model with respect to the consumer price of fluid milk is weakened. Interestingly, despite the sizable differences between the actual consumer prices and the theoretical ones, the potential gains from the efficient policy is relatively small—about IL741,000 per interest group. If there are some secondary political and administrative considerations in favor of a smaller gap between consumer prices of the two products, the failure of the model should not be overrated. Indeed, any such model is likely to fail in discerning variations to which the objective functions are insensitive. Finally, it is also possible that erroneous price elasticities were used,[7] or policy makers may have acted on erroneous ones (for more on this "problem of conformity," see Tinbergen 1954), or both. Evidently, errors in the estimation of the economic structural parameters may bias estimates of the power coefficients. Thus, the estimated power of the consumers' group depends on the price elasticities of demand used in the analysis. The greater the elasticity, the more sensitive is the consumer surplus to variation in prices and the more sensitive is the estimates of consumers' power. Since the elasticities of demand for dairy products are relatively small, we conjecture that the sensitivity of the estimates is also low.

Consumer price relationships deserve some further attention. First, the actual imputed value of raw milk allocated to the production of fluid milk, net of processing cost, is IL429.4 per kiloliter, while the corresponding value of raw milk processed into other dairy products is only IL261.4 per kiloliter. Recalling the difference in the elasticities of demand for the two products, the observed pricing behavior obviously involves an element of price discrimination. The surprising finding of the analysis is, however, that a policy change directed at the simultaneous increase in the well-being of all groups entails a further accentuation of the discriminating behavior. This is another manifestation of the "second-best" principle.

The introduction of milk production quotas as target variables of the farm sectors sheds new light on the power structure. Moshav farms now appear more powerful, reflecting the power relations that enable producers to force imports down and domestic production up, despite governmental opposition.

At this point one may wish to examine the normative implications of the analysis. Clearly, if one adheres to economic surpluses as the appropriate measures of social welfare, the Israeli dairy program is badly distorted. Even with the given policy instruments, the well-being of every group could be greatly enhanced. (This can be verified from the last row in table 1.) However, given that farm leaders continue to emphasize the output level as a desired policy goal, and given their political power, there is little scope for further improvements (see column 5, table 1).

The Internal Structure of the Political Conflict

The analytic path followed in the present study leads to one more interesting relationship having to do with the internal structure of the conflict. Consider the matrix K whose elements k_{ij} are the derivatives of the objective functions with respect to the policy instruments evaluated at the equilibrium levels, i.e., $k_{ij} = \partial u_i / \partial x_{0j}$, evaluated at $x_0 = x_0^*$. This matrix is named the conflict matrix, since it expresses the conflict among interest groups concerning the desired changes in policy instruments. Clearly, the k_{ij}'s cannot have the same sign for all i. But there are more interesting structural aspects traceable through the conflict matrix.

Consider, for instance, the conflict matrix

[7] Thus, the standard error of estimate reported by Rimland for the price elasticity of demand for fluid milk is 0.034 ($t = 1.47$). Since the price elasticity of demand for other dairy products was obtained by combining estimated elasticities for several products, the corresponding statistic is not available. However, here, too, considerable errors in the estimates are not unlikely.

Table 2. The Conflict Matrix, Model I

Interest Group	Policy Instruments: Consumer Price of Fluid Milk (P_f)	Consumer Price of Other Dairy Products (P_p)	Domestic Production (Q)	Production Share of Kibbutz Farms (k)	Subsidy Rate (S)
Government (u_0)	−112	125,690	−156.7	0	−286,390
Kibbutz farms (u_1)	46,818	40,125	80.5	76,296,000	100,500
Moshav farms (u_2)	35,818	40,107	29.1	−38,649,000	76,890
Consumers (u_3)	−137,010	−282,720	0	0	0

Note: Model I corresponds to $\beta = 2$.

presented in table 2, which corresponds to the model developed earlier (model I). Obviously, the two producers' groups agree on the desired direction of changes in all policy instruments except their relative shares of domestic production. Furthermore, the other interest groups are indifferent with respect to this particular instrument. Hence, relative shares are expected to be settled as an internal matter of the producing sectors. Having settled the internal conflict, producers are expected to form a coalition vis- à- vis the other groups. But this is still a controversy-ridden coalition, for its members seem to disagree, for instance, on the merits of an increase in domestic production as compared with changes in other instruments. True, this may be a mere tactical point, but it is a disagreement nonetheless.

Additionally, the conflict on other policy instruments emerges as a complex structure involving all parties. The resolution process is, thus, complicated considerably. It turns out, however, that model I is not unique and the conflict may be restructured. For instance, why should the subsidy rate be regarded as the policy parameter while assigning the producer price of raw milk the role of an endogenous variable? Why not exchange roles, setting a fixed producer price and adjusting subsidies in accordance with actual sales. In fact, negotiations between farmers and the government were actually conducted in terms of a target producer price. The basic formulation of our model is not modified by this exchange of roles, although equations (12) and (13) are replaced by the following ones:

$$R = P_m Q - C_p \tag{22}$$

and

$$S = \frac{R - P_f q_f - P_p q_i}{Q} \tag{23}$$

The policy parameter is now the farm price of raw milk (P_m), while the subsidy rate (S) is an endogenous variable. The new formulation is referred to as model II. The conflict matrix of model II is given in table 3.

It is clear that the internal structure of the conflict has been thoroughly altered. In particular, consumers are now completely separated from producers, with the government occupying a central position. Furthermore, while there still exist some tactical differences among producers, they have been narrowed, as both groups are now indifferent with respect to consumer prices. The relative shares of production are still an internal matter of the producers' groups. a graphic presentation of the conflict structure is provided in figure 2.

According to our model, the equilibrium solution is invariant under the two models, since the set F of structural restrictions on the economic variables has not been altered. Nevertheless, there are some tactical differences. Thus, model II appears to be more advantageous to farmers and consumers alike. First, it minimizes internal friction among producer groups, thereby strengthening their coalition, and second, both consumers and producers avoid the confrontation among themselves inherent to model I. The significant fact is that negotiations among the various interest groups have actually conformed to the pattern implied by model II.

Concluding Remarks

In the present study, an attempt has been made to capture the behavioral regularities discernable in a sectoral political economy. To this end, an extended model has been developed and applied embracing the economic relations as well as the political power structure. The underlying theory was a combination of Tinbergen's (1954, 1956) concep-

Table 3. The Conflict Matrix, Model II

Interest Group	Policy Instruments: Consumer Price of Fluid Milk (P_f)	Consumer Price of Other Dairy Products (P_p)	Domestic Production (Q)	Production Share of Kibbutz Farms (k)	Producer Price of Raw Milk (P_m)
Government (u_0)	133,300	275,060	−302.6	0	−286,420
Kibbutz farms (u_1)	0	0	131.8	76,273,000	100,550
Moshav farms (u_2)	0	0	68.3	−38,688,000	76,901
Consumers (u_3)	−136,700	−282,710	0	0	0

Note: Model II corresponds to $\beta = 2$.

tion of quantitative economic policy and the Nash-Harsanyi model of a bargaining game. The study may, therefore, be regarded as an empirical test of the underlying theory. How well, then, did the model fare in this experiment? Admittedly, the explanatory power of the model was not entirely convincing, but, as the analysis has shown, the failure may in

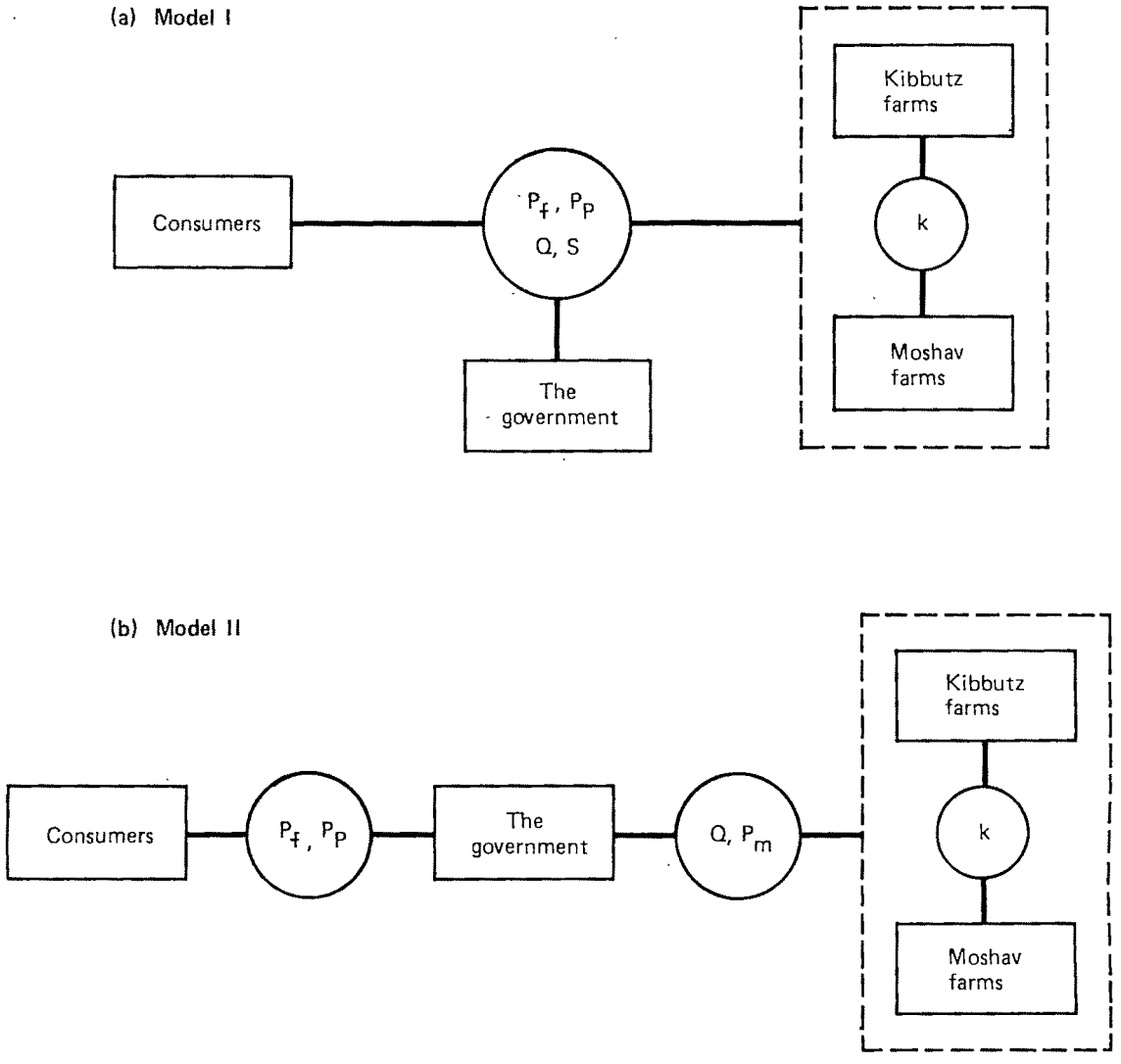


Figure 2. The internal structure of the conflict

effect become a blessing in directing the investigator's attention to necessary revisions in his formulation, shedding additional light on structural and behavioral characteristics of the system. Moreover, it is not unlikely that political-economic systems do involve a strong unexplainable element.

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An Evaluation of the Common Agricultural Policy as a Barrier Facing Agricultural Exports to the European Economic Community

Gary P. Sampson and Alexander J. Yeats

The influence of the European Economic Community's Common Agriculture Policy on world agricultural prices and exports of producing nations is analyzed. CAP reduces demand for agricultural imports, imparting more inelasticity into the world demand for them. Increased inelasticity amplifies price fluctuations born by non-EEC producers. Results stress the need for incorporating the subject of agricultural protection into the agenda of the current multilateral trade negotiations. Since CAP can amplify fluctuations in world agricultural prices, the system has a direct detrimental effect on non-EEC producers. CAP's potential for trade restriction, under levies and other protectionist measures, is significant.

Key words: agricultural protectionism, agricultural trade, Common Agricultural Policy, European Economic Community, trade barriers.

For a variety of reasons, nations such as the United States, Canada, and Australia are generally acknowledged to possess natural advantages over the European Economic Community (EEC) in the production of a wide range of agricultural commodities. The EEC, in turn, has competitive advantages in the production of some manufactured and durable goods. Since traditional economic theory leads us to believe that the level of global welfare is maximized when nations produce and trade those items in which they have a comparative advantage, it is in the best interests of agricultural exporting nations and the EEC to facilitate the international exchange of these commodities.

Over the course of the last decade, an issue of steadily increasing controversy has centered on the trade restrictions imposed on agricultural products by the Common Agricultural Policy (CAP) of the EEC. Proponents of this system argue that a primary objective of CAP is internal producer income maintenance and stabilization and, as such, it cannot be considered in trade liberalization negotiations.[1] This view has been bitterly contested by potential exporters of agricultural commodities who have found their products effectively blocked by the EEC's variable levies and other related measures. Adding to the confusion has been the lack of systematic empirical studies aimed at evaluating the magnitude of the trade barriers posed by the system.[2]

Since much relevant data are now available, the trade restrictive effects of CAP need not be left entirely to conjecture. The purpose of this study is to attempt such an

Gary P. Sampson is a senior lecturer in economics, Monash University, Melbourne, Australia, and Alexander J. Yeats is first economics officer in the Research Division, United Nations Conference on Trade and Development, Geneva, Switzerland.

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[1] In both the Kennedy and current Tokyo rounds of multilateral trade negotiations, the EEC has refused to have the issue of the Common Agricultural Policy placed on the formal agenda. This action has been taken in the face of strong protests from agricultural-exporting nations.

[2] Using Sweden, which also makes use of variable levies, as a case study, Sampson and Yeats demonstrated that the trade barriers posed by MFN tariffs may be insignificant in comparison to the restrictive effect of levies (1976a). In addition, Wipf has made some estimates of the *ad valorem* incidence of the EEC's variable levies and noted that many were over 50% and even reached 300% in the case of butter.

evaluation. While the frequency with which all known nontariff barriers are applied by the EEC is analyzed, this investigation places particular emphasis on variable levies. We concentrate on levies since these special import charges form the cornerstone of the Common Agricultural Policy and are among the most widely used measures to control agricultural imports. Levies are given special attention also since data are now available for empirically assessing their importance through estimation of tariff equivalents.

This paper proceeds in three parts. First, we discuss the main features of the Common Agricultural Policy and show how variable levies are used to control the flow of imports. The importance of levies as a trade barrier is demonstrated through comparisons of their *ad valorem* incidence on agricultural products with that of current most favored nation (MFN) tariffs. In making these comparisons, we draw heavily on the effective protection concept to show how these measures influence the protection for value added in a production process.[3] After this analysis is an evaluation of the other protectionist measures (i.e., quotas, minimum import price schemes, state trading, etc.) employed by the EEC. While the exposition here is largely descriptive due to problems in quantifying the effects of these restraints, clearly these measures are important supplementary devices (to levies) for restricting agricultural trade. The paper closes with an overall evaluation of the Common Agricultural Policy and its impact on agricultural-exporting nations.

The Common Agricultural Policy: An Overview

The EEC's treaty of Rome created the Common Agricultural Policy as a vehicle for achieving the specific objectives set forth in Articles 38–40: to create a common market in agricultural products, increase agricultural efficiency, provide a fair standard of living for the agricultural community, stabilize markets, ensure security of supply, maintain reasonable prices for consumers, and develop world trade harmoniously (Commission of the European Communities). To achieve these ends, an intricate system of protectionist devices and production aids has evolved over the last decade. This system, which now covers more than 90% of total EEC agricultural output, involves a mass of market regulations, including schemes for internal price support, external protection measures (e.g., tariffs and levies) and production subsidies.[4] However, it should be kept in mind that none of these measures need to operate independently. For example, the degree of external protection required to keep domestic prices competitive with world prices varies inversely with the support provided by production subsidies.[5]

While regulations differ according to commodities, the basic philosophy of the Common Agricultural Policy regarding internal price support and external protection has evolved out of the 1962 regulations for the marketing of grains.[6] The three key elements of this program are as follows.

(*a*) A basic target price (P_t) is established each year in advance of the following crop year. This price is intended to serve as a guide for producers in allotting future acreage. Since transportation charges will influence price differentials within the EEC, the target price is set as the delivered (cost,

[3] Essentially, effective protection measures the percentage change in value added from free trade levels that is permitted by the structure of a country's tariffs and other protectionist measures. For basic references on the topic, see Corden or Grubel. Economists have generally been reluctant to apply the effective rate concept to agricultural products due to a previous lack of empirical information on the incidence of nontariff barriers to trade, such as levies. The new data sources on *ad valorem* rates for these charges rectify much of this deficiency. Recent studies have demonstrated that problems in estimation of production coefficients, or substitution among factors of production, may bias effective protection estimates (see, for example, Sampson 1974 or Yeats 1976). Since both these factors may influence the estimates shown in this analysis, they should be regarded with some caution.

[4] For example, 72% of agricultural production is covered by price support schemes plus external protection, while 25% of total output has exclusively external protection. In general, price-support programs have been applied to products in which the EEC wishes to maintain self-sufficiency. Finally, supplementary production aid covers 2.5% of production, and aid at a fixed rate per hectare accounts for 0.6% (see Commission of the European Communities, p. 12).

[5] Specifically, production subsidies permitted the domestic price of olive oil to fall to 64% of the producer price over 1967–72. In this situation, external protection was lower than would have been required in the absence of this support. High production subsidies on olive oil result in reduced demand for other products, i.e., peanut oil, coconut oil, etc., that have a high cross elasticity of demand.

[6] Grains are of central importance to the EEC, accounting for half of the total cropland. Also, as a major input into the production of some commodities, their price is an important factor influencing the required level of protection in other sectors. For a more detailed discussion of the grains price support program, see UNCTAD (1967) or OECD.

insurance and freight) price in Duisberg, Germany.[7]

(*b*) An intervention price (P_i) is the price guaranteed to producers. More than 400 intervention and marketing centers have been established throughout the EEC and stand ready to accept all quantities of cereals offered at this floor price. While there is variation on a product by product basis, the intervention price is generally not more than 10% below the target price.

(*c*) Threshold prices (P_h) are used to insulate domestic EEC prices from fluctuations in world price (P_w) levels. The threshold price is equal to the basic target price minus transport costs from a fixed port of entry to the center of largest deficit. Imports from non-EEC countries are then subject to a variable levy that equals the excess of the threshold price over the world price.

The interconnections between these various prices and the functioning of the levy system can best be expressed in symbolic form. In equation (1) below, the target price is established at a certain fixed level k. Equation (2) shows the relation between the intervention price and the target price, while equation (3) indicates that the threshold price is equal to the target price minus internal (EEC) transport charges. The key to this system, equation (4), shows that the variable levy fluctuates to maintain equality between world and domestic EEC prices.

$$P_t = k, \tag{1}$$

$$(P_i - 0.1P_t) \leq P_i \leq P_t, \tag{2}$$

$$P_h \equiv P_t - T_d \tag{3}$$

and

$$L_i \equiv P_t - (P_w + T_d), \tag{4}$$

where $L_i \lesseqgtr 0$.

Evaluation of the relationship shown in equation (4) indicates how the variable levies operate to restrict demand for foreign agricultural products. By incorporating a variable charge (L_i) into the delivered price of imports, the system maintains foreign prices at or above those received by domestic producers. When levies are positive they hold demand for imported agricultural products below levels that would prevail in their absence.

While the above demonstrates that variable levies restrain import demand, these charges also have an adverse, destabilizing effect on natural fluctuations in world agricultural prices. Thus, while the Common Agricultural Policy serves to insure stability for domestic producers, it does so by augmenting the instability in prices born by foreign producers by increasing the inelasticity of world demand curves.

Variable Levies: An Empirical Assessment

A point that follows from the previous analysis is that the trade effects of variable levies are related to the ratio P_t/P_w. Thus, the higher the EEC target price is above world levels, the greater the *ad valorem* incidence of levies on imports, and the larger the curtailment of potential import demand.

For information on these *ad valorem* rates, a General Agreement on Tariffs and Trade document is used. Essentially, this study approximates nominal rates for the variable levies (N_L) by tabulating revenues from these charges as a percentage of the total value of imports:

$$N_L = \sum L_i Q_i / \sum P_i Q_i, \tag{5}$$

where P_i and Q_i are prices and quantities of six-digit Brussels Tariff Nomenclature (BTN) items imported into the EEC over the period 1969–70.[8] In general, these ratios are computed for each six-digit BTN item to which a levy is applied. However, in some cases these import charges are apparently set at levels sufficient to restrict trade ($\sum P_i Q_i = 0$), with the result that an *ad valorem* incidence cannot be estimated.

Table 1 illustrates the importance of variable levies for products classified in SITC 0 (food and live animals) and SITC 4 (animal and vegetable oils). Shown here is the per-

[7] Duisberg was selected since it represents the greatest grain deficit (i.e., production minus consumption) region in the EEC.

[8] Since imports from overseas departments of the EEC member states, from the overseas territories associated with the EEC, and from associated African and Malagasy states are included in the denominator, there is reason to believe that the estimated *ad valorem* incidence is biased downward. Imports from these sources are normally admitted levy free, but apparently they could not be broken out from the six-digit BTN figures.

Table 1. Nominal Protection for EEC Agricultural Products and 1974 Value of Australian Exports

Product Description	SITC	EEC Coverage by Levies		Nominal Protection (%)			Australian Exports ($ million)	
		Tariff Lines	Value of Trade ($ million)	Tariffs	Levies	Total	EEC	World
Food and live animals	0							
Food and live animals	00	33.4	1,828	11.8	18.2	30.0	228	42,059
Meat and meat preparations	01	39.5	188,887	18.1	30.4	48.5	72,253	665,568
Dairy products and eggs	02	29.4	892	18.4	152.9	171.3	257	224,362
Fish and fish preparations	03	0	0	12.8	—	12.8	5,294	99,959
Cereals and preparations	04	41.9	355,330	15.2	52.1	67.3	26,160	1,719,700
Fruits and vegetables	05	8.2	91,936	16.4	37.1	53.8	67,818	143,092
Sugar and honey preparations	06	38.5	97,075	53.1	12.0	65.1	65,263	690,263
Coffee, tea, cocoa, and spices	07	6.9	0	10.8	51.0	61.8	206	15,599
Feeding stuff for animals	08	8.4	11	5.4	56.0	61.4	1,089	24,123
Miscellaneous food preparations	09	13.4	8	19.2	47.3	66.5	544	8,476
Beverages and tobacco	1							
Beverages	11	0	0	27.0	—	27.0	2,388	19,889
Tobacco manufactures	12	0	0	61.4	—	61.4	[a]	5,696
Animal and vegetable oils	4							
Animal oils and fats	41	9.6	14	3.5	31.8	35.3	7,802	58,190
Fixed vegetable oils and fats	42	15.8	16,640	11.4	39.2	50.6	[a]	3,258
Processed animal oils and fats	43	11.2	0	7.5	1.1	8.6	1,206	4,782

[a] Australian exports to the EEC were less than $1 million.

centage of trade in each two-digit Standard International Trade Classification (SITC) group covered by levies, as well as similar information on the tariff lines subject to these special charges.[9] For purposes of comparison, we have estimated both the average *ad valorem* tariff and levy rate for these groups and have also computed their joint protective effect. Finally, to assist in evaluating the influence of these charges on one important agricultural exporting nation, we have tabulated Australian exports of these products to the EEC as well as to all other destinations.

Perhaps the most striking feature in table 1 concerns the relative height of the average nominal tariff and average *ad valorem* equivalent of the variable levies. In SITC 0, for example, a nominal tariff rate of 18% is coupled with levies whose average rate is approximately three times this figure. Only in the case of SITC 06 (coffee, tea, cocoa, and spices) is the incidence of the variable levies less than that for tariffs. The primary reason for this departure is a tariff rate that averages over 50%. Much the same picture concerning the relative importance of these import charges can be observed in SITC 4 (animal and vegetable oils), where average tariffs of approximately 8% are coupled with levies of 24%.[10] On an overall basis, these groups enjoy protection of over 60% from tariffs and levies, with roughly two-thirds of the total from levies.

A product-by-product comparison shows the total nominal rates of protection facing a large proportion of these agricultural products are extremely high. For example, when levies are combined with tariffs, the nominal rate for dairy products and eggs is over 170%. Cereals and preparations face a combined trade barrier of almost 70%, while nominal rates of protection for meat and sugar are both about 50%. The impact of these charges can be appreciated by noting that they reduce the EEC's share of Australian exports

[9] The tariff line is the most disaggregate level of product detail used for classifying imports and is employed for determining applicable tariffs and other trade restrictions.

[10] While the value of the variable levy may be changed frequently, published estimates of their incidence over the period 1967–71 indicate that the figures shown in table 1 are generally representative of their longer-term levels. For some products, however, they may be low. For example, during 1968–69 and 1969–70, the *ad valorem* incidence of the levies was over 500% on butter while that for sugar ranged from 110% to 330% (see UNCTAD 1972). There are a number of other agricultural or related products falling in SITC 2 (crude materials). However, the incidence of tariffs and nontariff barriers (NTB's) on these items are not analyzed due to the large number of two-digit component products that are distinctly nonagricultural in nature (i.e., fertilizers, metal ores, etc.).

to less than 10% for these key products, while the share of these items in the value of exports constitutes 40% of the Australian total.

While the beverage and tobacco group is not subject to levies, protection from tariffs has been substituted. For example, tobacco manufacturers face an average tariff rate of over 60%, while a nominal rate of 27% is applied to beverages. In assessing this latter figure, it should be noted that transportation costs for such items may constitute a high percentage of product price.[11] Thus, tariff protection for bulky, low-value products need not be set as high as that for other products, since transportation costs provide a natural trade barrier. The overall impression that emerges from table 1 is that artificial protectionist measures such as tariffs and levies have been set at very high levels and constitute an imposing barrier to trade in agricultural products.

Effective Protection of Agricultural Products

While the previous analysis provided an overview of the coverage and importance of variable levies, it told nothing about the influence of these charges on the protection of value added (the effective rate) in a production process.[12] Yet the protection of value added is of key importance, since this indicates the extent to which foreign producers must operate with direct costs lower than their EEC counterparts in order to penetrate this market.[13]

Information required for the estimation of effective protection rates was drawn from data compiled in the United Nations Conference on Trade and Development (UNCTAD) secretariat in connection with preparations for the Tokyo round of tariff negotiations. Essentially, the data required for the estimation of the required production process input shares come from national input-output tables, although in some cases this information was supplied by Food and Agricultural Organization experts (through correspondence).[14] This data was employed, with information on the EEC's tariffs and variable levies, to estimate the effective protection stemming from each of these charges on imports.[15]

Table 2 shows the estimated effective protection rates for these agricultural products and also indicates nominal rates of protection. To assist in evaluating these results, effective protection estimates derived separately from tariffs and levies are given as well as that for their combined effect. Finally, the table shows average nominal and effective rates for these products.

Perhaps the most interesting feature in table 2 concerns the relative importance of tariffs and levies as sources of protection against imports. For the nine farm gate products, an average tariff rate of 14% already presents an imposing trade barrier, yet the additional nominal protection from levies (45%) is roughly three times this figure. Much the same pattern is observed for the processed agricultural products as an average tariff rate of 18% is combined with a nominal rate for levies of 75%. Only in one case out of the twenty-three products with joint coverage (meal and groats) is the nominal tariff rate larger. Altogether, the evidence from these comparisons suggests that variable levies are a far more important source of protection for agricultural products then current MFN tariffs.

[11] For example, Sampson and Yeats (1976b) found that the average 1974 *ad valorem* incidence of transport costs for Australia's beverage exports to the United States was roughly 30%. Fruit and vegetables had an *ad valorem* rate of 38%, while meat and dairy products had rates of 13% and 15% respectively. While this study concentrates on penetration costs for the U.S. market, evidence is presented to show that the transport rates should be roughly the same for the EEC.

[12] The effective rate of protection E_j for a product j is normally defined as

$$E_j = (V_j' - V_j)/V_j, \tag{6}$$

where V_j is the value added coefficient in a free trade situation and V_j' is this share under protection. Effective rates differ from nominal rates in that the latter only measures protection for the final product, while the former measures the protection for value added in a production process.

[13] For example, the effective rate of protection in a production process with a free trade value added coefficient of 40%, and nominal tariffs of 20% and 10% on the end product and material inputs, is 35%. In order to sell in such a protected market, foreign producers would have to operate with a remuneration of productive factors 26% below that in the protected market.

[14] For a detailed discussion of how the input coefficients are estimated, as well as a discussion of other aspects of this study, see Yeats (1974).

[15] If r_i and η are the *ad valorem* equivalents of variable levies on material inputs and the final product, while t_i and t_j are the nominal tariffs on these items, then the effective rate of protection from both elements is

$$E_j = ((t_j + \eta) + \Sigma\, a_{ij}(t_i + r_i))/V_j, \tag{7}$$

where a_{ij} is the free trade share of production input i. Obviously, the effective rate of protection by tariffs and levies combined is the sum of the effective rate from each element.

Table 2. Comparison of Nominal and Effective Rates of Protection for Selected Agricultural Products in the EEC

Description	Nominal Rate (%)		Effective Rate (%)		
	Tariffs	Levies	Tariffs	Levies	Total
Farm gate products					
Oats	13.0	84.2	25.8	177.9	203.7
Rye	16.0	75.8	32.1	160.0	192.1
Wheat	20.0	73.0	40.6	154.1	194.7
Rice	16.0	34.5	32.1	72.8	104.9
Maize	6.0	34.1	10.7	72.0	82.7
Sheep	14.8	[a]	33.7	−42.7	−9.0
Swine	15.8	26.4	37.7	34.4	72.1
Poultry	12.0	15.9	25.5	3.8	29.3
Bovine animals	15.2	16.0	34.9	5.0	38.9
Meat products					
Bovine meat	20.0	64.2	38.2	215.2	253.4
Pig meat	20.0	30.4	36.7	52.9	89.6
Mutton	20.0	20.0	39.3	80.0	119.3
Poultry meat	18.0	23.3	38.5	51.9	90.4
Preserved fruits and vegetables	26.0	26.8	62.5	199.2	161.7
Grain products					
Corn flour	8.0	45.3	10.4	85.6	96.0
Wheat flour	25.0	76.4	98.9	206.8	305.7
Other flour	8.3	37.5	−2.8	41.9	39.1
Rolled cereal flakes	26.9	33.4	95.4	19.5	114.9
Meal or groats	23.0	17.3	75.6	−51.2	24.4
Roasted and puffed cereals	8.0	24.9	−14.9	−52.2	−67.1
Fodder	14.8	35.2	61.2	62.8	134.0
Macaroni and spaghetti	12.0	43.7	6.7	50.6	57.3
Dairy products					
Cheese	23.0	82.5	58.8	217.2	276.0
Butter	21.0	328.0	76.5	1,244.2	1,322.7
Condensed and exaporated milk	21.3	98.5	44.3	290.1	334.4
Tobacco products[a]	87.1	—	148.5	—	148.5
Leather products[a]	7.0	—	21.4	—	21.4
Vegetable oils[a]					
Soybean oil	11.0	—	148.1	—	148.1
Groundnut oil	7.5	—	92.9	—	92.9
Coconut oil	8.0	—	70.3	—	70.3
Average	18.2	56.1	49.3	134.1	158.1

Note: The average values shown for the variable levies exclude those products not covered by these special import charges.
[a] Variable levies are not applied to this product group.

Similar conclusions concerning the relative importance of tariffs and levies emerge from comparisons of the effective protection estimates. For the farm gate products, an average effective tariff rate of 30% is coupled with effective protection of 63% from levies. However, in the case of livestock, variable levies on grains and other basic feeds raise producer costs and reduce effective protection below corresponding levels for tariffs.[16] A similar pattern emerges for some of the processed grain products (i.e., meal and groats, puffed cereals, etc.) where levies on the basic input artificially inflate production costs.

[16] A number of other nontariff trade restraints are applied to these items, and their influence may offset the reduced effective protection from levies. For example, sheep imports are subject to quotas, special licensing restrictions (France), and minimum import price restrictions.

On an overall basis, effective protection from levies averages 134%, roughly two-and-a-half times the effective tariff rate. However, certain key products—meat, cereals, fruits, and vegetables—face an average effective protection rate of 150% or more, with the major portion of this protection associated with variable levies. Undoubtedly, protection set at these levels is a primary reason why Australia's exports to the EEC have been held to the low levels indicated in table 1.

Application of Other Nontariff Restraints

While the preceding sections empirically evaluated the trade barriers posed by the

EEC's tariffs and variable levies, there is a variety of other nontariff trade restrictions applied to agricultural imports by the community. Unfortunately, it is difficult to quantitatively assess the influence of these measures since *ad valorem* equivalents have not yet been calculated. However, a tabulation of their frequency of use and products to which they are applied is helpful in providing an indication as to their importance as obstacles to international trade.

Using information drawn primarily from UNCTAD's multilateral trade negotiation data base,[17] table 3 shows the types of nontariff restraints applied to various agricultural products. The impression that emerges from this inventory is that an extensive and complex system of controls has been established to effectively regulate or limit foreign competition for domestic producers. While variable levies are applied to fourteen of these three-digit product groups, the table indicates that quotas or other quantitative restrictions are used with almost equal frequency. Table 3 also shows that special licensing arrangements are used for controlling imports of nine of the three-digit products, while state trading is employed for regulating imports of certain meat and cereal products. The most prevalent type of trade obstacle agricultural-exporting nations face are special preferences for associated countries. Since these measures reduce the MFN tariffs (or levies) for beneficiaries, they do much to offset the comparative advantages that countries like Australia, Canada, or the United States have in the production of some of these products.

[17] This data bank has been prepared to assist less developed countries in evaluating the number and types of NTB's applied to their exports by industrial countries. For references concerning the construction of and output from this project, see UNCTAD (1973, pp. 36–39).

Conclusions

This paper analyzed the influence of the Common Agricultural Policy on agricultural

Table 3. Nontariff Trade Barriers Facing Agricultural Exports to the EEC

Description	SITC	Nontariff Trade Restraint[a]
Live animals	001	PHS, R, SP
Meat, fresh chilled or frozen	011	HS, PHS, DL, GQ, R, MP, ST, VL, SP
Meat in airtight containers	013	HS, PHS, R, DL, VL, SP
Milk and cream	022	VL
Fish and fish preparations	031	SP, Q, BQ
Wheat and meslin unmilled	041	VL, SP
Rice	042	VL, SP
Barley unmilled	043	VL, SP
Maize unmilled	044	VL, SP
Other cereals unmilled	045	VL, SP
Meal and wheat flour	046	VL, SP
Meal and cereal flour	047	VL, SP
Cereal preparations	048	VL, SP, ST, HS
Fresh fruit and nuts	051	HS, GQ, BQ, SP, R, SR, DL, SR
Dried fruit	052	DL, HS, Q
Preserved fruit	053	BQ, Q, HS, DL, GQ, VL, SP
Preserved vegetables	054	SP, BQ, DL
Vegetable roots and tubers	055	SP, HS, BQ, GQ
Sugar and honey	061	VL, SP, PHS, L, HS, BQ
Coffee	071	SP
Cocoa	072	SP
Cocoa and cocoa food preparations	073	SP, HS, BQ, LL, DL
Tea and maté	074	SP
Feeding stuff for animals	081	VL, SP
Food preparations, nes.	099	SP, L, BQ, DL
Alcoholic beverages	112	R, SP, HS, ST, DL, LL
Tobacco manufactures	122	DL, GQ, SP
Fixed vegetable oils	422	SP
Processed animal and vegetable oils	431	SP, R, DL

[a] Restrictions applied in whole or in part to the SITC group. The key to these symbols is as follows: PHS, HS = prohibitions due to health and sanitary reasons, or health and sanitary regulations; SP = special import preferences for states associated with the EEC; Q = quotas (method unspecified) or bilateral quotas; GQ = global quota; DL, LL = discretionary licensing or liberal licensing of imports; L = import licensing (method unspecified); VL, MP = variable levy or other minimum import price restrictions; R, SP = restrictions (method unspecified) or special seasonal restrictions; and ST = state trading.

prices and exports of producing nations. After specification of a simple algebraic model to illustrate the operation of the system, it was demonstrated that the Common Agricultural Policy has the capacity to reduce demand for agricultural imports. The system also imparts a greater degree of inelasticity into the demand curve for these items. The effect of the increased inelasticity is to amplify price fluctuations borne by foreign (non-EEC) producers. This induced price instability is quite apart from the disruptions in world markets caused by the disposal of agricultural surpluses that occasionally build up under the Common Agricultural Policy. Thus, while proponents of the system may argue that the Common Agricultural Policy is a vehicle for achieving domestic price stability, this is undoubtedly accomplished by reducing imports and transferring instability to foreign producers.

To assist in evaluating the trade restrictive nature of the Common Agricultural Policy, the *ad valorem* incidence of the EEC's variable levies are computed. When these figures are compared for a variety of agricultural imports (table 1), the restrictive effect of the levies is seen to be more than double that of current MFN tariffs on these items (44% versus 20%). however, for some important products, i.e., dairy products, cereals, etc., the *ad valorem* incidence of the variable levies is considerably higher. When viewed within the framework of the effective protection model, the trade barriers posed by the Common Agricultural Policy are found to be even more imposing. Furthermore, the analysis indicates that there are a number of other important trade barriers applied to agricultural imports by the EEC, although the exact magnitude of their influence could not be quantified.

For several reasons, the results contradict the argument that the Common Agricultural Policy is solely an income maintenance and stabilization program and therefore not subject to trade liberalization negotiations. Since the Common Agricultural Policy can amplify fluctuations in world agricultural prices, the system has a direct detrimental effect on non-EEC producers. Also, the Common Agricultural Policy's potential for trade restriction, under levies and a variety of other protectionist measures, are indeed significant. No inherent reason exists why these trade control measures should be treated differently within the context of the current multilateral trade negotiations from those measures applied in the nonagricultural sector.

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Agricultural Sector Models and Their Interface with the General Economy (Karl A. Fox, Iowa State University, Chairman)

The Wharton Agricultural Model: Structure, Specification, and Some Simulation Results

Dean T. Chen

Econometric analysis is sometimes criticized because it has failed to make a substantial contribution to forecasting and policy formulation in agriculture. We are told of the various avenues by which improvement in agricultural forecasts can be made through the use of econometric models. A primary conclusion drawn by speakers at the 1976 AAEA annual meeting points to the need for a large-scale, integrated agricultural sector model for on-going and on-line use. The need for an improved forecasting system to encounter massive recent changes in agriculture was suggested by Fox (1973), who found us ill prepared in terms of data, models, and analytical procedures for the tasks of forecasting and policy formation. A study of several well-known macroeconometric models by Popkin further supports this view because almost two-thirds of the average prediction error of econometric inflation forecasts in recent years could be traced to the changes in exogenous prices, among which the farm and food prices are the key components.

Improvements of agricultural price forecasts were initially suggested within the context of a macromodel itself, e.g., by adding a number of behavioral equations and restructuring the price transmission mechanism. However, because of the gap existing between the complexities of farm commodity markets and the simplified nature of the agricultural sector specification in macromodels, little can be expected from such an enhancement. An integrated view of the agricultural economy in general and market behavior of individual commodities in particular is needed. Capturing the interdependence and providing coordination can be greatly facilitated by considering a full-size, multipurpose agricultural sector model. Work in this direction has several precedents (e.g., Fox 1965, Cromarty, Evans), but none of these models have actually been used in applied work; therefore, a fresh start is needed.

Agricultural economists have constructed an impressive number of econometric models at the commodity level (see Labys or King). Scattered attempts at commodity models have been poorly integrated with national or agricultural forecasting systems, severely limiting their uses in practical work. This leads to the so-called traditional paradox of "meaningful parts forming meaningless whole" in agricultural model research (Tweeten, p. 181). A lack of comprehensive and sustained effort was cited as a key deterrent to agricultural econometric forecasting. The most neglected aspect of model research is on forecasting evaluation, which is the best means for pinpointing biases and for improving forecast performance. If structural estimation, theory testing, and prediction are integral parts of one larger econometric problem (Klein 1971a), model building and especially forecasting application should re-

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Dean T. Chen is the director of Agricultural Model and Services, Wharton Econometric Forecasting Associates, Philadelphia, Pennsylvania.

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ceive more attention by agricultural economists.

Objectives and Approach

For any model-building work, careful consideration must be given to two conceptually different but practically related methodological issues: modeling applications and the modeling process. Given the current state of knowledge and analytical needs, the model builder's attention should be directed not only toward the "true" economic structural relations as a close approximation to economic reality but also to the design of a reliable and sensible tool for practical uses. In pursuit of this goal, the model presented in this paper has been constructed.

The design of the Wharton Agricultural Model reflects its purposes. (*a*) As a short-term econometric forecasting model, it is useful for quarterly forecasts of supply, demand, and prices of individual farm commodities and for the determination of farm income and expenditure flows. (*b*) As a simulation instrument, the impacts of alternative conditions of weather, government farm programs, farm commodity export and world crop production, and macroeconomic policy can be analyzed. (*c*) As an analytical tool, it can be used for sensitivity analysis of the market adjustment mechanism, the interactions among the farm and nonfarm sectors, and the international linkages between U.S. and foreign agriculture.

A useful model should be constructed on a quarterly basis with a great degree of commodity detail.[1] A quarterly model is favored over an annual model because decision making in agriculture has been influenced by short-term agricultural developments, e.g., seasonal crop development, livestock numbers on farm, and rapid fluctuations of export demand conditions. A systematic and rigorous analysis of quarterly data could contribute greatly to forecasting efficiency and policy precision. Proponents of intertemporal disaggregation suggest that such a model would have the least bias, the least simultaneity in the system of economic relationships, and the least specification error concerning causal directions and, at the same time, might not give rise to greater serial correlations in disturbance terms (e.g., Liu and Hwa).

When one considers the gap between what econometric models forecast and what business users need to forecast, the choice of the larger, more complex model is inevitable. Business leaders have long been dissatisfied with the divergent development of the "theoretical model" and the "user model" (Crowder, Cromarty and Myers). This phenomenon is indeed a serious one, but there is a tendency to a gradual narrowing of this gap. After all, other than for the advancement of economic theory and econometric methodology, econometric models are constructed for the purpose of practical application. Unquestionably, there must be common ground in terms of problem orientation and technical orientation guiding model-building work in agriculture.

The limitations of large simultaneous equation systems as summarized by Cromarty and Myers are difficulty in adjusting to structural changes, rigidity imposed by internal consistency, the management of a large, complex information system, and the inability to predict exogenous variables that are specified as endogenous variables in larger models. However, given existing computer technology and econometric techniques, some of these difficulties are being overcome. The size and complexity appears to be less of a methodological issue nowadays because, as long as a model can be constructed and maintained economically and effectively, there should be little objection to bigness. In order to gain insight and flexibility, any part of a large model actually can be isolated and run as a separate entity. For this reason, a large model may have the advantages of both largeness and smallness especially with a multicommodity framework. The Wharton macromodel experience indicates a historical trend toward bigness. User requirements and the advantage of spreading risks all push toward the development of larger models (Klein 1971b).

Another consideration important to modeling applications is related to data. A useful model must be so constructed to follow a schedule closely tied to the quarterly release of economic data by government statistical agencies. As data are obtained from original sources and updated quickly and reliably, there is need to choose the right data series

[1] As a comparison to other models, Cromarty's and Evans's are annual models, while the FOX-SSRC Brookings is a quarterly model but lacks commodity details.

for the right variables. A basic strategy is to develop the model with sufficient points of contact with the U.S. Department of Agriculture information system, especially those of the Crop and Livestock Reporting Board, the Outlook and Situation Board, and the newly implemented Computerized Outlook Information Network (COIN).

The Overall Model Structure

The Wharton Agricultural Model can best be described by considering it to be subdivided into four blocks of equations: the intercommodity block, the annual crop production block, the income-expenditure block, and the micro-macro linkage block.

Among the four interrelated blocks, the intercommodity block is undoubtedly the heart of the model, containing simultaneously determined quarterly equations of supply, demand, inventory, and price relations for seventeen commodities or commodity groups. For the livestock sectors, the model provides detailed information of animals on feed, commercial production, per capita retail demand, and prices received by farmers for six commodities: cattle and calves, hogs, dairy, broilers, turkeys, and eggs. The information to be forecast for the crop sectors includes stocks on and off farm, domestic utilization (for feed, food and industry, and seed), export sale, and average prices received by farmers. The model covers eleven major crops: food grains (wheat, rice, and rye), feed grains (corn, sorghum grains, oats, and barley), soybeans (soybean oil and soybean meal), cotton, tobacco, vegetables, and fruits.

The actual and prospective changes in annual crop production have often played a pivotal role in the short-term development in agriculture. Moreover, projections of annual crop production are a starting point for any meaningful analysis of changes in government farm programs as well as current weather development. The annual crop production block is thus not only an important forecasting device for a timely evaluation of the prospects for each crop but also is useful for impact simulations. In formulating production response, two behavioral equations (planted acreage and yield per harvest acre) and an identity for total crop production are generally needed. To complete the crop production identity, an important exogenous variable, the harvested acreage as a percentage of planted acreage, must be included. This variable is used as a proxy variable for weather impact study if it can be explained by actual weather data such as rainfall and temperature. Unlike the intercommodity block, which contains quarterly and simultaneous equations, this block is annual and recursive.

The income-expenditure block provides the main statistical identities relating the income and expenditure accounts for the agricultural sector of the U.S. economy. For farm income components, the relationships are basically definitional, reflecting the standard concepts and procedures in the derivation of cash receipts from farm marketings, realized gross farm income, realized net farm income, and total net farm income. Since the intercommodity block provides information about prices and volume of farm supply of individual commodities, such information can be used to generate cash receipts from farm marketings, both in total and by commodity. Given farm cash receipts, the realized gross farm income can be derived by adding the nonmoney income and government payments. The realized net farm income is the difference between realized gross farm and farm production expenses, while the total net farm income is the sum of realized net farm income and the net changes in farm inventory. A two-step procedure was employed to determine the equation for farm prices paid, which in turn is used to determine the farm production expenses equation. In addition, the net changes in farm inventories are also treated as an endogenous variable to reflect the stages of farm commodity cycles and inventory adjustment mechanism in business cycles.

The micro-macro linkage block provides a set of bridge equations to treat the agricultural sector in similar form and specification as other production sectors of the economy by focusing on aggregate demand components, output origination, wage, labor and employment, sector prices and final demand prices, farm income, and personal income components. With the completion of the linkage block, a full feedback relationship between the agricultural sector and the macromodel can be expected. It also allows for testing the agricultural implications of macroforecasts and macroimplications of agricultural forecasts.

Simplified Specification of the Model

I now review briefly the issues concerning the modeling process: specification, estimation, and simulation. As the surveys by Labys and by King indicate, commodity model builders have encountered a host of problems and difficulties in recent years. Most notable are the specification problems due to the omission of monetary and speculative factors, the failure to link the model in a multicommodity framework, the difficulty in modeling climatic conditions, the inability to measure export demand fluctuations, and the weakness in the analysis of inventory and price dynamics.

In developing a model, it is important to evaluate each of the problem areas mentioned above and to design strategies for possible improvements. In essence, agricultural markets are characterized by uncertainty in weather and export demand conditions, by lagged responses to price changes, and by nonlinear supply and demand relations. These attributes of uncertainty, dynamics, and nonlinearities form the basic theoretical foundation for improvements of the model. In this study, the effects of weather on crop production were modeled by a multistage impact analysis of acreage, yield, and production through the entire planting, growing, and harvesting seasons. The weather impact analysis was also considered as a direct argument in the price determination equation by using nonlinear probability variables of crop forecast revision. A novel feature involves the development of an internal dynamic system that describes a complex set of interrelated adjustment processes in the feed-livestock economy. A low-order polynomial lag formulation was employed to investigate the lag response pattern of livestock on feed, as well as the demand for feedgrains and soybean meal relations. The nonlinearities were included in both export demand and price equations, helping to track the recent gyrations of these variables. Broadly speaking, the model is structured around the traditional microeconomics framework to determine supply-demand balances and complementary and substitution relations of individual commodities and group of commodities.

In the simplified specification shown in table 1, the agricultural sector of the U.S. economy is represented by twenty-two structural relations in three major equation blocks.[2] A brief comment of the special features of the model is in order.

Equations (1) through (5) describe the feed-livestock complex, including the complete livestock model and the demand for feed component for crops. This specification is designed to take explicit account of the feed-livestock interdependency. Reflecting a complex set of interrelated adjustment processes, the model provides a mechanism to link changes in relative prices to livestock supply as well as demand for feed functions. This adjustment mechanism involves four responses—(*a*) the response of potential output due to producers' adjustment of feeding and hatchery operations: the time path of adjustment varies among commodities, and a flexible lag structure of low-order polynomial was adopted because it showed promising results in another study (Chen, Courtney, and Schmitz); (*b*) the response of actual output due to changes in expectations and adjustments of marketing plans: as producers' marketing decisions are constrained by anticipated net revenue flow, negative supply response to price is expected in the short run (Jarvis); (*c*) the effect of derived demand for feedgrains and soybean meal: the adjustment intensifies by livestock on feed as well as rate of feeding; (*d*) the influence of changes in livestock output and feed consumption on prices for these products: generation and successive generation of this internal dynamic adjustment process help determine the relevant endogenous variables in the system.

Weather impact analysis constitutes a challenging methodological issue in agriculture. Since reliable weather forecasts are currently not available for more than a few days ahead, the best a serious forecaster can do is to evaluate current weather information to determine the size of crops. While such an approach is useful, the result may not be very different from the official USDA estimates or private forecasts. From an econometric modeling point of view, the task is to analyze weather impact on market conditions, especially on price development. A basic advantage of this approach is that when extreme weather conditions occur, we can spot, identify, and analyze their significance for forecasting and policy purposes.

[2] In early stage of model development, the micro-macro linkage equations are taken from the current version of the MARK IV Wharton quarterly model.

Table 1. Simplified Specification of the Wharton Agricultural Model

I. Intercommodity block (quarterly and simultaneous)

Livestock sector

(1) Supply response for feeding and hatchery operations

$$LVKSF_i\text{: } \sum_{L=0}^{K} \alpha_L \left[\frac{LVKPF_i}{\dfrac{\sum_{j=1}^{4} CRPPF_j \cdot CRPDF_j}{\sum_{j=1}^{4} CRPDF_j}} \right]_{-L}, S_d, Z_{1i}$$

(2) Farm supply function

$$LVKAP_i\text{: } \frac{LVKPF_i}{\dfrac{\sum_{j=1}^{4} CRPPF_j \cdot CRPDF_j}{\sum_{j=1}^{4} CRPDF_j}}, LVKSF_i, S_d, Z_{2i}$$

(3) Retail demand function

$$LVKPF_i\text{: } \frac{LVKRD_i}{TCPOP}, \frac{RDPI}{TCPOP}, LVKPF_s, RCLVK, S_d, Z_{3i}\ (s \neq i)$$

(4) Supply-utilization balance (identity)

$$LVKRD_i = LVKAP_i \cdot W_i - LVKMX_i + LVKMI_i + \Delta LVKHT_i$$

Subscripts i and j above stand for commodity disaggregations for livestock and crops, where $i = 1, \ldots, 6$ for cattle, hogs, dairy, broiler, turkey, and eggs and $j = 1, \ldots, 4$ for corn, sorghum grains, oats, and barley.

Crop sector

(5) Demand for feed

$$\frac{CRPDF_j}{\sum_{i=1}^{6} \delta_i \cdot LVKSF_i}\text{: } \sum_{L=0}^{N} \beta_L \left[\frac{CRPPF_j}{\dfrac{\sum_{i=1}^{6} LVKPF_i \cdot \delta_i \cdot LVKSF_i}{\sum_{i=1}^{6} \delta_i \cdot LVKSF_i}} \right]_{-L}, \left[\frac{SOMPM44DE}{\dfrac{\sum_{i=1}^{6} LVKPF_i \cdot \delta_i \cdot LVKSF_i}{\sum_{i=1}^{6} \delta_i \cdot LVKSF_i}} \right], \frac{CRPPF_j}{CRPPF_s}, S_d, X_{5j}\ (s \neq j)$$

where $j = 1, \ldots, 7$ for corn, sorgnum grains, oats, barley, wheat, rye, and soybean meal.

(6) Demand for food and industry

$$\frac{CRPDH}{TCPOP}\text{: } \frac{CRPPF}{PDCENF}, \frac{RDPI}{TCPOP}, \frac{.WRHBP}{PDCENF}, S_d, X_6$$

The subscript j, denoting the individual crop sectors, is omitted. The cross-commodity specification described by equations (6) through (14) cover, if data are available, a total of nine crops in the present version of the model: wheat, rice, rye, corn, sorghum grains, oats, barley, soybeans (soybean oil and soybean meal), and cotton.

(7) Demand for seed

$$CRPDS\text{: } CRPSA, CRPSP/DS, \frac{CRPPF}{CRPEU}, X_7$$

(8) Export demand function

$$CRPMX\text{: } \frac{CRPPF}{DEV}, \frac{CRPPF_j}{CRPPF_s}, \frac{GDPW}{POP}, STK/L4M4 \cdot MIN, SPW/USM4 \cdot MIN, Sd, X_8\ (s \neq j)$$

Two of the nonlinear variables, $STK/L4M4 \cdot MIN$ and $SPW/USM4 \cdot MIN$ in equation (8) are

$$STK/L4M4 \cdot MIN = \left(\frac{1}{4} \sum_{i=0}^{3} \left(\frac{STK}{STK_{-4}} \right)_{t-4} - MIN \frac{1}{4} \sum_{i=0}^{3} \left(\frac{STK}{STK_{-4}} \right)_{t-i} + 0.1 \right)^{-1}$$

and

$$SPW/USM4 \cdot MIN = \left(\frac{1}{4} \sum_{i=0}^{3} \left(\frac{PROW/POP}{CRPSP/TCPOP} \right)_{t-1} - MIN \frac{1}{4} \sum_{i=0}^{3} \left(\frac{PROW/POP}{CRPSP/TCPOP} \right)_{t-1} + 0.1 \right)^{-1}$$

Table 1. Continued

(9) Price determination

$$CRPPF\text{: } CRPHT/DT\cdot MIN,\ \frac{1}{4}\sum_{t=0}^{3}\left(\frac{CRPMX}{CRPHC+F}\right)_{t-1},\ CRPSP\cdot DE.P,\ Sd,\ X_9$$

where $CRPHT/DT\cdot MIN = \left[\left(\frac{CRPHT}{CRPDT}\right) - MIN\left(\frac{CRPHT}{CRPDT}\right) + 0.1\right]^{-1}$ and $\overline{CRPSP\cdot DE.P} = \left[\pi - \frac{d\varepsilon - \overline{d\varepsilon}}{\sigma_{d\varepsilon}}\right]^{-1}$,

$E(d\varepsilon - \overline{d\varepsilon}) = 0$, var $(d\varepsilon) = \sigma_{d\varepsilon}^2$, and π is determined by $Pr\left[-\pi < \frac{d\varepsilon - \overline{d\varepsilon}}{\sigma_{d\varepsilon}} < \pi/\phi = 60\right] = 0.9995$.

(10) Supply-utilization quarterly balance (identity) with linkage to annual crop productions

$$\Delta CRPHT = CRPSP\cdot\Omega_s \begin{cases} = \gamma_s \text{ for harvest quarters} \\ = 0, \text{ otherwise} \end{cases} + CRPMI - CRPDT$$

where the seasonal crop allocation factor is

$$\Omega_s \text{ and } \sum_{s=1}^{4}\gamma_s = 1\ (s = 1, \ldots, 4)$$

(11) Aggregate and individual demand components (identify)

$$CRPDT = CRPDF + CRPDH + CRPDS + CRPMX$$

II. Multistage crop production response (annual and recursive)

(12) Acreage, yield, and production identity

$$CRPSP = CRPSA\cdot\frac{CRPSH}{CRPSA}\cdot CRPSY$$

(13) Planting season acreage response

$$CRPSA\text{: } \frac{CRPPF}{CRPEU},\ \frac{CRPPF_j}{CRPPF_s},\ CRPPD,\ CRPPE,\ PASWC,\ X_{13}\ (j \neq s)$$

(14) Growing and harvest season analysis of yield per acre

$$CRPSY\text{: } CRPSA,\ \frac{CRPSH}{CRPSA},\ \frac{CRPPF}{CRPEU},\ T_{xy},\ X_{14}$$

III. Income and expenditure flow (quarterly and recursive)

(15) Determination of livestock cash receipts

$$CRLVK_i\text{: } LVKPF_i\cdot LVKAP_i,\ V_{15i}\ (i = 1, \ldots, 6)$$

(16) Determination of crop cash receipts

$$\ln CRC_j\text{: } \ln (CRPSP_j\cdot CRPPF_j),\ \ln CRPHF,\ S_d,\ V_{16j}\ (j = 1, \ldots, 11)$$

(17) Determination of total cash receipts

$$CR\text{: } \sum_{i=1}^{6} CRLVK_i + \sum_{j=1}^{11} CRC_j,\ Sd,\ V_{17}$$

(18) Realized gross farm income identity

$$YFRG = YFMGNP + CR$$

(19) Prices paid by farmers

$$\ln PFPC^*\text{: } \ln PDIBF,\ \ln LVKPFW,\ \ln FGPFW,\ \ln XAG,\ V_{19}$$

(20) Farm production expenses function

$$EXFP\text{: } XAG,\ PFPC^*,\ V_{20}$$

(21) Realized net farm income identity

$$YFRN = YFRG - EXFP$$

(22) Realized total farm income, identity

$$YFTN = YFRN + INFNC$$

Table 1. (continued)

Endogenous Variables

CR	= Cash receipts, total $ billion annual rate
CRLVK	= Cash receipts, livestock
CRC	= Cash receipts, crop
CRPDF	= Crop, domestic utilizations for feed
CRPDH	= Crop, domestic utilizations for food and industry
CRPDS	= Crop, domestic utilization for seed
CRPDT	= Crop, total utilized (disappearance)
ΔCRPHT	= Crop, changes in total stock
CRPMX	= Crop, total U.S. exports
CRPPF	= Crop, U.S. average prices received by farmers
CRPSA	= Crop, U.S. annual total acreage planted, crop year
CRPSP	= Crop, U.S. annual total production, crop year
CRPSY	= Crop, U.S. yield per acre harvested, crop year
EXFP	= Farm production expenses, $ billion annual rate
FGPFW	= Weighted average prices, feed grain
INFNC	= Net change in farm inventories, $ billion annual rate
LVKAP	= Livestock, commercial productions, live weight
LVKPF	= Livestock, average prices received by farmers
LVKPFW	= Weighted average prices, livestock
LVKRD	= Livestock, per capita retail demand, dress weight
LVKSF	= Livestock, animals on feed or hatchery operation, head
*PFPC**	= Average prices paid by farmers, index (1967 = 100)
YFRG	= Realized gross farm income, $ billion annual rate
YFRN	= Realized net farm income, $ billion annual rate
YFTN	= Total net farm income, $ billion annual rate

The key exogenous variables involve five major categories to reflect the simulation capabilities of the model: government policy, weather impact, general economic conditions, world economics and agricultural conditions, and the others.

Exogenous Variables

.WRHBP	= Average hourly earnings, U.S. bakery products industry
**MIN*	= Minimum value in the sample period
CRPEU	= Crop, index of fertilizer prices
CRPHC+F	= Crop, farm and commercial stock, beginning of quarter
CRPHG	= Crop, CCC stocks own facilities, beginning of quarter
CRPMI	= Crop, total imports
CRPPD	= Crop, U.S. effective diversion payment rate
CRPPE	= Crop, effective support rate
CRPSH/CRPSA	= Crop weather condition proxy, harvested acreage as percentage of planted acreage
CRPSP/DE	= Productivity trend, seed production
CRPSP·DE.P	= Crop nonlinear probability variable of crop forecast revision
DEV	= Exchange rate, SDR's per U.S. dollar
GDPW	= World domestic product, weighted by agricultural production (1968 = 100)
ΔLVKHT	= Livestock, changes in stock of cold storage
LVKMI	= Livestock, total imports
LVKMX	= Livestock, total exports
PASWC	= Range conditions, previous fall
PDCENF	= Implicit deflator, personal consumption expenditure of nondurables, food and beverage (1958 = 100)
PDIBF	= Implicit deflator, fixed investment, total (1958 = 100)
POP	= Population, world total
PROW	= Crop, world total production
RCLVK	= Livestock, farm-to-retail spreads
RDPI	= Real disposable personal income
Sd	= Seasonal dummy variable, 1 for the quarter and 0 otherwise
SOMPM44DE	= Soybean cake and meal prices
SPRMLK	= Milk, support price for manufacturing grade milk
STK	= Crop, carryover stocks, total for world major exporting countries
TCPOP	= U.S. total civilian population
TECGPL480$	= Volume of U.S. agricultural exports under PL-480
Tsy	= Crop, productivity trend of yield per acre
Vi	= Farm income, other exogenous variables and disturbance term

Table 1. (continued)

W_l	= Livestock, conversions factor from live weight to dress weight
XAG	= Gross product originating agriculture, forestry and fisheries
Xi	= Crop, other exogenous variables and disturbance term
YFMGNP	= Farm income—nonmoney and government payment
Zi	= Livestock, other exogenous variables and disturbance term
δ_l	= Weight factors, grain consuming animal units
β_L	= Distributed lag coefficients, second-order polynomial, with N period lags
$d\varepsilon$	= Crop, deviation from expectation of annual crop production
α_L	= Distributed lag coefficients, second-order polynomial with K period lags
ϕ	= Degree of freedom
Ω_s and γ_s	= Seasonal crop allocation factors

The proposed weather impact analysis is based on an evaluation of the crop expectation and realization process and its impact on price determination. The variable *CRPSP·DE.P* (equation (9)) is constructed for that purpose. Given early season crop production estimates (March planting intentions) as the baseline forecast, the subsequent revisions are defined as $d\epsilon$, where $d\epsilon$ is baseline forecast minus the subsequent forecast in a given quarter. Under normal weather conditions, $d\epsilon - \overline{d\epsilon} = 0$, so that *CRPSP·DE.P* is a constant $(1/\pi)$. Whenever extreme weather conditions develop, they can be measured in terms of standard deviations. Since *CRPSP·DE.P* is a nonlinear term, as the crop forecast is revised downward, the price impact increases rapidly. Therefore, this approach is useful for drought impact analysis.

The price determination formulation follows Adams and Behrman, who have treated stock-demand ratios in a nonlinear fashion as a principal explanatory variable in price equations. As the stock-demand ratio approaches the minimum historical level, the price impact increases rapidly. The same type of function is used in the export demand function (equation (8)) for which world stock and production variables are used.

A unique feature of the acreage and production response equations is the possibility of evaluating the crops through various seasons of a crop year. The impact of weather and government farm program can be fully analyzed with respect to planting, growing, and harvest ramifications. To link the annual crop production with the quarterly supply-demand-stock balance, a seasonal crop production allocations factor is used in equation (10).

Simulation Results

The theoretical relationships specified in the preceding section represent a simultaneous equation system of 249 equations, of which 101 are stochastic, the others being identities and definitions. This model was estimated by the ordinary least squares (OLS) method using data during 1945-74 for annual equations and from 1959.1 to 1974.4 for quarterly equations. Apparently, the direct applications on OLS to structural equation yield acceptable results regardless of built-in biases. Given the small sample available and the nonlinearities involved in the specification, the advantage of simultaneous equation estimators remains uncertain. Nevertheless, it may be useful to test the feasibility of an iterative instrumental variable procedure (Klein 1971a) for possible improvement in predictive efficiency.

In view of space limitations the estimated equations are not presented, nor do I attempt a detailed explanation of the results. In general the model shows quite satisfactory results in terms of the signs and magnitudes of the coefficients, goodness of fit, and other test statistics. Having examined the model equation by equation, the next logical step is to test it as a complete entity. Two basic simulation experiments have been carried out to test the model for its *ex post* forecasting performance as well as its sensitivity to exogenous shocks. Among the various criteria proposed for model evaluation (e.g., Dhrymes et al.), these two tests are most commonly employed prior to the release of the models.

The summary statistics of the *ex post* predictive testing in table 2 were taken from static and dynamic simulations of the complete model from 1968.2 to 1974.3. For comparison purpose I also include the single equation solution for the entire sample period. To perform this simulation experiment, the actual values of the exogenous variables and the initial values of the endogenous variables were used to solve the model simultaneously through an iterative procedure

Table 2. Error Analysis in the Wharton Agricultural Model

	Root-Mean-Square Error as Percentage of Mean		
		Complete Model Simulation	
	Single Equation (Sample Period)	Static (1968.2–1974.3)	Dynamic (1968.2–1974.3)
Prices, income, and expenditure			
Prices received by farmers	0.19	5.28	6.75
Prices paid by farmers	0.06	4.71	4.53
Total farm cash receipts	0.71	8.21	8.93
Farm production expenses	0.37	4.69	8.40
Realized gross farm income	Identity	9.00	10.04
Livestock (sample commodity: beef cattle)			
Cattle on feed 23 states (1,000 head)	0.76	3.53	7.97
Beef cattle, commercial liveweight slaughter (billion lbs.)	0.53	2.57	5.23
Beef per capita retail demand (lb./capita)	Identity	2.34	4.79
Cattle, average price received by farmers ($/cwt.)	0.81	4.43	5.11
Crops (sample commodity: corn)			
Corn, average price received by farmers ($/bu.)	2.14	14.60	15.53
Corn, utilized for feed (million bu.)	1.46	11.56	14.04
Corn, utilized for food and industry (million bu.)	0.37	3.14	3.16
Corn, total change in stocks (million bu.)	Identity	7.47	8.98
Corn, total exports (million bu.)	2.67	16.94	16.88
Acreage planted, yield, and production (sample commodity: corn)			
Corn, acreage planted (million acres)	0.66	4.41	8.98
Corn, yield for grains (bu./acre)	1.08	6.53	6.52
Corn, production for grain (million bu.)	Identity	6.94	7.09

with a convergence factor of 0.5%. The predictive capabilities of the model are described by the root-mean-square error as a percentage of the sample mean. Cattle and corn were chosen to represent the livestock and crop sectors, respectively. The resulting statistics indicate that during one of the most difficult time periods for agricultural forecasts the model performs quite well. Most of the endogenous variables are tracked very closely by the model, particularly the overall farm price indexes, farm income, and farm expenditure components. At the commodity level, the livestock forecasts are generally better than crops. The price and export demand functions of corn are relatively poorer performers, but their prediction errors in the dynamic simulation are quite similar to those in the static solution. This phenomenon is particularly encouraging because error accumulation has long been recognized as a serious problem to dynamic predictions.

The second simulation experiment concerns the model's ability to respond to external shocks. First, a "control" solution is calculated and then one or more of the exogenous variables are changed by a preassigned amount to generate a "disturbed" solution. One of the most interesting simulations is the drought impact analysis on crop prices. We would expect that the extreme weather conditions of 1973–74, the so-called triple whammy of spring flood, summer drought, and early frost, had strong upward price effects in the year. The drought impact analysis was calculated by assuming "normal weather" conditions, which implies that the early season crop production expectation (March planting intention multiplied by normal yield) remain unchanged until actual harvest. From this simulation experiment, the "normal weather" corn prices were found to be $2.29 and $2.40 per bushel in 1974.3 and 1974.4, compared with the actual prices of $3.19 and $3.34 in the same period. To summarize the simulation experiments, the model shows promise for short-term forecasting and analysis. While development of im-

provements and enhancements will be a continuing effort, we hope to learn a great deal from repeated applications to *ex ante* forecasting.

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Agricultural Activity and the General Economy: Some Macromodel Experiments

Joseph M. Roop and Randolph H. Zeitner

Spectacular growth in the size and complexity of econometric models has undoubtedly aided economists in understanding relationships within the macroeconomy. These models are not wholly satisfactory in the view of agricultural economists because they have no agricultural sector that allows an investigation of the interaction between the macroeconomy and agriculture. This is unfortunately true, despite the fact that a number of agricultural sector models have been developed specifically for inclusion within a large macromodel (e.g., Cromarty, Fox).

Macromodel builders have adopted one of two strategies to capture the effects of agriculture on the macroeconomy. They either structure agriculture as a satellite model or consider the important behavioral variables in the agricultural sector as being determined outside of the macroeconomic model. A satellite model is separate from the macromodel in the sense of providing no estimates of endogenous variables but relies on forecasts of variables generated by the macromodel (Adams). The second strategy considers agriculture as an industrial sector but relies on variables outside the model to better characterize the impacts that agriculture has on the macroeconomy; i.e., the sector is treated as essentially exogenous.

The aim of this study is first the construction of an agricultural sector model that is self-contained and could be run as a small satellite model and, second, the integration of the agricultural sector model into a large macromodel, in this instance the one developed by Wharton Econometric Forecasting Associates known as the Wharton Mark IV.

Joseph M. Roop and Randolph N. Zeitner are economists with the National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture.

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The interested reader can find a discussion of the predecessors of the Mark IV in Evans and Klein and in McCarthy. For the purpose at hand, the agricultural sector of Mark IV is discussed in the following section. The agricultural sector model is then described, tested as a satellite, and then integrated into Mark IV by eliminating some of the Wharton specified equations and adding our own. The concluding section summarizes our work up to this point and suggests some of the ways we plan to further this work in the future.

Wharton Mark IV Agricultural Sector

Five behavioral equations in Mark IV describe economic activity within the agricultural sector. Fixed nonresidential agricultural investment (*IAAG*) is determined by the ratio of the implicit price deflator for agricultural output to the user cost of capital, a distributed lag of past output, and lagged value of the estimated error (Cochrane-Orcutt technique). Output originating in agriculture (*XAG*) is determined by only one explanatory variable, personal consumption expenditure for nondurable food and beverages. The implicit deflator associated with *XAG* (*PXAG*) is determined by prices received and prices paid, both taken as exogenous. Compensation per man-year (*WRCAG$*) is determined by distributed lags of three explanatory variables, the potential unemployment rate (*CVWNRUT*), the consumer price index (*PC**), and the ratio of output to agricultural employment (*XAG/NEHA*). The ratio of proprietary farm income (*YENTF$*) to the current value of agricultural output is explained by the ratio of prices received to prices paid (*PFR** and *PFPC**, both exogenous variables).

The linkages of the implied agricultural sector with the rest of the economy are both direct and indirect. Farm investment and the change in farm inventories (*IBIF*, considered exogenous) in real terms are elements of aggregate investment demand, a component of real gross national product (GNP). Output originating in agriculture is added to other industry outputs and reconciled with the GNP. After prices are computed, including the implicit deflator for agricultural output, the current value of GNP is determined. National income, including proprietary farm income, is calculated by an identity relation that includes the wage bill in agriculture. Farm prices received enter directly into the determination of the unit value index of food exports (*PTEEGDF*) and the change in the wholesale price index of crude materials (*PWPC**). In an indirect fashion, the implicit sector deflator (*PXAG*) enters into the determination of most other implicit deflators. All the implicit deflators for the components of aggregate demand are estimated as a ratio to weighted averages of the industrial sector implicit deflators, the weights having been derived from a separate input-output study. Thus, a current quarter increase in *PXAG* will enter into the determination of most other prices in the same quarter.

An Aggregate Agricultural Sector Model

The main distinction between the proposed agricultural sector model (AGSEC) and the sector model described in the previous section is that AGSEC relies on the income statement as used in the National Income and Product Accounts (U.S. Dep. Commerce). By this definition, current output includes the value of commercially sold goods, the value of home consumption, rents, and the change in farm inventories. From total output, intermediate purchases are subtracted and other items added to yield gross farm product. Farm income is derived by adding transfer payments and subtracting both capital consumption allowance and indirect business taxes. Income can then be disaggregated into four components: wage compensation, interest, proprietors' income, and profits. This sector income statement is contained in the following three identities (table 1 contains a description of the variables):

Table 1. Variable Identification

Variable	Description
CCARNTAG	Depreciation rate, agriculture
CENF	Consumption expenditure, food
CRCCC	Cash receipts plus net CCC loans
CUWIPMFD	Capacity utilization index, manufacturing durables
CVWNRUT	Potential unemployment rate, civilian labor force
CCAAG	Depreciation expenses, agriculture
DPVAG	Discounted current value of depreciation
DUMDOCK	Dummy for dock strike
DUMITL	Dummy, investment tax credit, Long amendment
DUMSA01(02,03)	Seasonal dummies, first to third quarters
DUMTIME	Dummy, time
FMRCS	Yield on corporate bonds
IAAG	Investment, new plant and equipment, farm
IBIF	Change in farm inventories, constant dollars
IBIF$	Change in farm inventories, current dollars
ITREAG	Effective investment tax credit rate
KIAAG	Capital stock, agriculture
KIBIF	Real value of inventories
LQTAG	Effective tax life, agricultural equipment and structures
NEHA	Agricultural employment
OER	Other exogenous receipt items
OI	Other items
OPEXP	Purchases of intermediate products
*PC**	Consumer price index, all items
PDCENF	Implicit deflator, *CENF*
PDIBFN	Implicit deflator, total fixed investment
*PFPC**	Prices paid, farm
*PFR**	Prices received, farm
*PFR*12*	Thirteen-period moving average of *PFR**
PTEEGDF	Unit value index, exports, food
*PWPC**	Wholesale price index, crude materials
*PWPI**	Wholesale price index, intermediate materials
*PWPFP**	Wholesale price index, finished producers goods
PXAG	Implicit deflator, agriculture
RIRAG	Intermediate variable used in computation of *UCKAG*
TAG-IBT	Transfer payments less indirect business taxes
TXRITEFAG	Effective corporate tax credit rate, agriculture
UCKAG	User cost of capital, agriculture
WBCAG$	Wage bill in agriculture
WRCAG$	Compensation per man-year in agriculture
WRCMF$	Compensation per man-hour in manufacturing
XAG	Output originating in agriculture, real terms
XAG$	Current value of *XAG*
XQMKT	Index of volume of marketings

Table 1. (Continued)

Variable	Description
YCORP	Net corporate income in agriculture
YENTF$	Net farm income, proprietors
YOAGI	Interest component of income in agriculture
YPDPC$	Disposable personal income per capita
YAG$	Income originating in agriculture

(1) Gross farm product (*YAG$*):

$$\underset{(w)}{XAG\$} = CRCCC + \underset{(w)}{IBIF\$} + OER - OPEXP + OI,$$

(2) Farm sector income (*YAG$*):

$$YAG\$ = XAG\$ - CCAAG + (TAG - IBT),$$

and

(3) Net proprietors' farm income (*YENTF$*):

$$\underset{(w)}{YENTF\$} = YAG\$ - \underset{(w)}{WBCAG\$} - YOAGI - YCORP.$$

The parenthetical *w* denotes variables in the agricultural sector of Mark IV.

The major structural components of *AGSEC* are described by equations that estimate farm prices received (*PFR**), prices paid (*PFPC**), an index of the quantity of marketings (*XQMKT*), and the value of intermediate products (*OPEXP*). Both price equations are estimated as price-dependent derived-demand equations for outputs and inputs of the farm sector. The value of intermediate products is estimated recursively based on the value of current output and prices paid for inputs. The quantity of marketings is estimated as a business response variable allowing *XQMKT* to respond to current price, an expected normal price, and the current value of inventory stocks. The variable *XQMKT* is a Paasche index constructed to allow the determination of the major component of total output—cash receipts—by the following identity:

(4) Cash receipts (*CRCCC*):

$$CRCCC = PFR^{*} \cdot XQMKT \cdot 0.042825.$$

A flow diagram in figure 1 provides an overview of the structure of the model. For those interested in more detail, the estimated equations are available upon request.

The restructured model of the agricultural sector (AGSEC) contains nine behavioral equations, the four previously cited plus one for each of the following: investment (*IAAG*), employment (*NEHA*), implicit sector deflator (*PXAG*), wage compensation per man-year (*WRCAG$*), and depreciation expense (*CCAAG*). In addition to the four identities mentioned, there are identities for current value of inventory changes and stocks, the current value of investment, user cost of capital, the wage bill, and the real value of farm output.

All behavioral relations were estimated by ordinary least squares over 1955–75. Adjustments were made for autocorrelation using the Cochrane-Orcutt iterative technique. There are a total of twenty variables exogenous to AGSEC, nine of which are endogenous to Mark IV. The version of Mark IV reported in this paper contains 460 endogenous variables and 207 exogenous variables. Thus, when AGSEC and Mark IV are solved together, there are 469 endogenous variables and 216 exogenous variables.

AGSEC as a Satellite: Solution and Simulations

AGSEC cannot be solved by deriving the reduced form from a linear transformation of the structural parameters because the model is nonlinear. To solve the model, the Gauss-Seidel iterative solution technique, as documented in Heien, Matthews, and Womack, is used. Both static and dynamic simulations were performed over 1969–75, years which were included in the period of fit. Summary measures for both simulations are given in table 2.

The variables directly estimated have smaller percentage errors than those solved through identities. Seven of the variables have a mean percentage error greater than 5%, four of which are derived from accounting identities. One would expect that the system would perform better when actual lags are used (static simulation) rather than when lags are computed (dynamic). Table 2 affirms this supposition in this case if the criteria are anything but the Theil *U*-statistic. In the static simulations, twelve variables

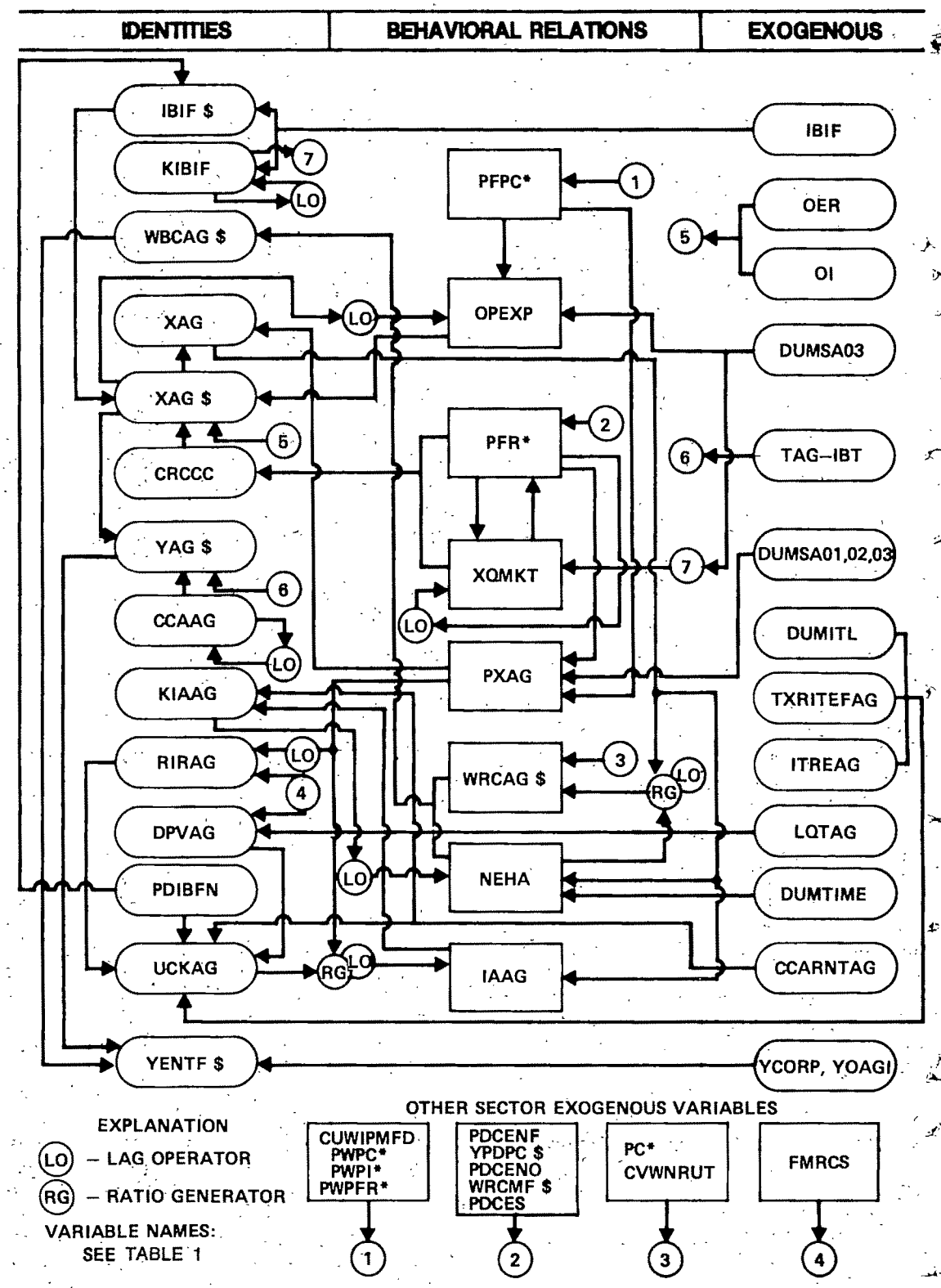


Figure 1. AGSEC: aggregate agricultural sector model

Table 2. AGSEC as a Satellite Model: System Measures

	Mean Error (%)	Mean Absolute Error (%)	RMS Error (%)	System R^2 Y vs. $\hat{Y}$	Theil U-Statistic	Mean Error (%)	Mean Absolute Error (%)	RMS Error (%)	System R^2 Y vs. $\hat{Y}$	Theil U-Statistic
	Static Simulation, 1969I–75IV					Dynamic Simulation, 1969I–75IV				
XAG$	−4.8	8.0	9.8	0.91	1.32	−9.5	12.9	15.8	0.88	0.93
CRCCC	−0.7	4.0	5.0	0.96	1.01	−0.9	7.2	8.3	0.93	0.76
OPEXP	−0.1	1.7	2.2	0.99	0.61	4.2	5.1	7.0	0.94	0.61
YAG$	−6.3	10.4	13.1	0.85	1.40	−12.1	15.6	19.2	0.81	0.98
CCAAG	0.2	1.2	1.8	0.99	0.96	−0.2	6.8	7.8	0.94	0.67
*PFR*12*	0	0.2	0	0.99	0.001	−2.4	4.2	5.3	0.94	0.45
YENTF$	−26.2	26.2	3.3	0.78	1.41	−32.1	32.6	39.3	0.76	0.97
WBCAG$	−3.3	7.1	9.1	0.81	1.71	−13.1	14.5	16.4	0.82	1.02
*PFR**	−0.9	4.4	5.0	0.95	1.17	−1.3	8.6	9.8	0.99	0.90
XQMKT	0.5	2.3	2.7	0.52	1.19	0.6	2.4	2.9	0.53	1.02
*PFPC**	0.3	0.9	1.2	0.99	0.54	0.7	1.4	1.9	0.99	0.39
NEHA	−1.0	5.7	6.4	0.06	1.25	−3.5	5.3	6.1	0.07	1.16
WRCAG$	−2.3	4.1	6.9	0.92	1.28	−9.2	9.8	11.7	0.91	0.91
KIAAG	0	0.1	0.1	0.99	0.33	1.0	1.1	1.7	0.99	0.39
IAAG	1.3	4.0	5.0	0.84	1.24	5.0	7.0	8.3	0.78	0.88
PXAG	−0.7	5.1	6.3	0.93	1.13	−0.6	9.4	11.5	0.87	0.90
XAG	−4.0	5.4	7.3	0.26	1.53	−9.0	9.2	10.9	0.29	1.30
	Static Simulation, 1975I–76II					Dynamic Simulation, 1975I–76II				
XAG$	−10.4	15.4	18.6	0.09	1.90	−23.6	23.6	25.6	0.25	1.18
CRCCC	−3.3	6.8	7.8	0.08	1.24	−8.9	8.7	9.9	0.62	0.84
OPEXP	1.4	3.7	4.1	0.35	1.40	5.0	5.0	5.4	0.60	0.86
YAG$	−15.5	22.1	27.8	0.22	2.02	−38.8	38.8	41.5	0.16	1.21
CCAG	1.3	2.6	4.8	0.70	2.83	17.5	17.5	17.9	0.05	1.12
*PFR*12*	0	0.01	—	0.99	0.001	−1.3	1.3	1.6	0.99	0.24
YENTF$	−47.3	47.3	61.8	0.22	2.05	80.4	80.4	85.2	0.12	1.22
WBCAG$	−0.5	3.7	4.4	0.37	1.18	−5.6	5.6	6.4	0.85	0.78
*PFR**	−2.0	4.5	4.6	0	1.90	−7.8	7.8	8.6	0.34	1.52
XQMKT	−0.2	3.1	3.4	0.18	1.08	0.1	2.8	3.3	0.26	1.00
*PFPC**	1.8	2.2	2.7	0.77	1.06	3.4	3.4	3.7	0.92	0.61
NEHA	4.2	4.4	5.3	0.07	1.55	3.2	3.4	4.2	0.04	1.34
WRCAG$	−4.8	5.1	6.9	0.54	1.09	−9.0	9.0	10.4	0.57	1.01
KIAAG	0.2	0.2	0.3	0.96	0.52	−0.1	0.3	0.3	0.87	0.62
IAAG	3.0	6.4	6.8	0.14	1.58	1.2	6.0	6.7	0.01	1.01
PXAG	−2.1	6.6	7.7	0.06	1.45	−9.7	9.7	11.4	0.42	1.11
XAG	−7.7	8.3	12.5	0.76	2.71	−12.7	12.7	14.8	0.68	1.96

perform "worse" than a naïve no-change model, while in the dynamic simulation only four are worse. For either simulations, these Theil U-statistics are disturbing. We conjecture that the model's performance can be substantially improved (in the concluding section this is elaborated on). Table 2 also reports static and dynamic simulation performed over the period 1975I–76II, the latter two quarters outside the sample period used for estimation.

For an understanding of the response dynamics of AGSEC, various multiplier analyses were performed, i.e., both impact (or one period) and longer (up to twenty periods). Since the total system is nonlinear, the effect of an increase in an exogeneous variable may not, in general, be the same as a decrease; but we expect them to be quite similar. Several of the multipliers are shown in table 3.

Unfortunately, a variable of considerable interest to the U.S. Department of Agriculture, net farm income (*YENTF$*), still has a large percentage error. Primarily for this reason, we feel that exploiting the model for policy implications at this time would be premature. As work progresses and we are better able to validate the structure of the model, we will be better able to replicate historical experience. Despite these obvious shortcomings, we decided to embed the model for two major reasons: to "debug" the software, and to see how the macroeconomic model would be affected by an altered agricultural sector.

Table 3. AGSEC Multiplier Analysis

Period After Shock	*XAG$*	*WBCAG$*	*OPEXP*	*NEHA*	*IAAG*	*PXAG*	*XAG*
	Percentage Change on Selected Variables Resulting from Exogenous Shocks						
	1% Change in *CUWIPMFD*						
1	−0.0134	−0.0062	0.0124	−0.0035	−0.0002	0	−0.0134
2	−0.0127	−0.0058	0.0119	−0.0029	−0.0006	−0.0017	−0.0110
3	−0.0126	−0.0050	0.0119	−0.0028	−0.0012	−0.0016	−0.0110
4	−0.0124	−0.0038	0.0118	−0.0028	−0.0021	−0.0016	−0.0108
5	−0.0123	−0.0029	0.0118	−0.0026	−0.0033	−0.0016	−0.0107
10	−0.0120	−0.0022	0.0117	−0.0016	−0.0084	−0.0016	−0.0104
15	−0.0118	−0.0012	0.0117	−0.0005	−0.0087	−0.0016	−0.0102
20	−0.0117	−0.0004	0.0117	0.0004	−0.0085	−0.0016	−0.0101
	1% Change in *YPDPC$*						
1	4.7135	0.4231	0.4177	0.2425	0.0122	3.7640	0.9151
2	4.4542	0.3688	0.5957	0.1828	0.1084	3.7246	0.7034
3	4.4026	0.3153	0.5855	0.1768	0.2587	3.6644	0.7122
4	4.3532	0.2255	0.5836	0.1574	0.4354	3.6367	0.6913
5	4.3101	0.1540	0.5818	0.1340	0.6191	3.6119	0.6747
10	4.1721	0.0188	0.5765	−0.0143	1.0027	3.5284	0.6217
15	4.1027	−0.0587	0.5742	−0.1142	0.7798	3.4851	0.5968
20	4.0677	−0.1353	0.5733	−0.1932	0.7870	3.4675	0.5801
	1% Change in *PWPC**						
1	−0.3243	−0.1502	0.3009	−0.0863	−0.0043	0	−0.3243
2	−0.3070	−0.1394	0.2872	−0.0704	−0.0138	−0.0408	−0.2663
3	−0.3040	−0.1207	0.2869	−0.0691	−0.0298	−0.0390	−0.2651
4	−0.3009	−0.0921	0.8861	−0.0667	−0.0517	−0.0300	−0.2620
5	−0.2983	−0.0712	0.2856	−0.0635	−0.0790	−0.0389	−0.2594
10	−0.2896	−0.0540	0.2840	−0.0379	−0.2038	−0.0388	−0.2509
15	−0.2852	−0.0298	0.2833	−0.0118	−0.2014	−0.0387	−0.2466
20	−0.2830	−0.0087	0.2831	0.0102	−0.2053	−0.0387	−0.2444

Integrating AGSEC and Mark IV

The solution software provided by Wharton Econometric Associates for solving the Mark IV model consists of a generalized Gauss-Seidel solution routine (the SOLVE program) using two subroutines (CONNIE and SIMON) to solve a model coded in FORTRAN. The CONNIE subroutine solves for the constant part of each equation, including any lagged predetermined variables, while the SIMON subroutine is used to solve for the current period simultaneous values. To embed the agricultural sector model into the Mark IV, the FORTRAN coding of the Mark IV was modified to eliminate the computation of variables specified by the model and augmented with additional subroutines containing the equations of AGSEC. A one-period, static simulation was then performed from 1974I–76I with both the augmented model again called AGSEC and the unaltered Mark IV (Mark 4).

A number of technical points are worth mentioning before reporting results. Time did not permit the variety of experiments we would like to have conducted nor has validation of AGSEC proceeded to the point where we feel confident that the important interactions between the agricultural sector and the macroeconomy are being captured; consequently, the results must be taken as illustrative rather than as an expression of the effect of the agricultural sector on the macroeconomy. The results show the impact on the macroeconomic model of the "raw" agricultural sector model, not one altered by constant adjustments to better replicate historical experience. Even though constant adjustments have not been used, the results are encouraging. Finally, space limits do not permit the reporting of many agricultural sector variables, so instead reporting of results is limited to macroeconomic variables on which one would expect an impact as a result of tinkering with the agricultural sector.

Six variables that might be affected by

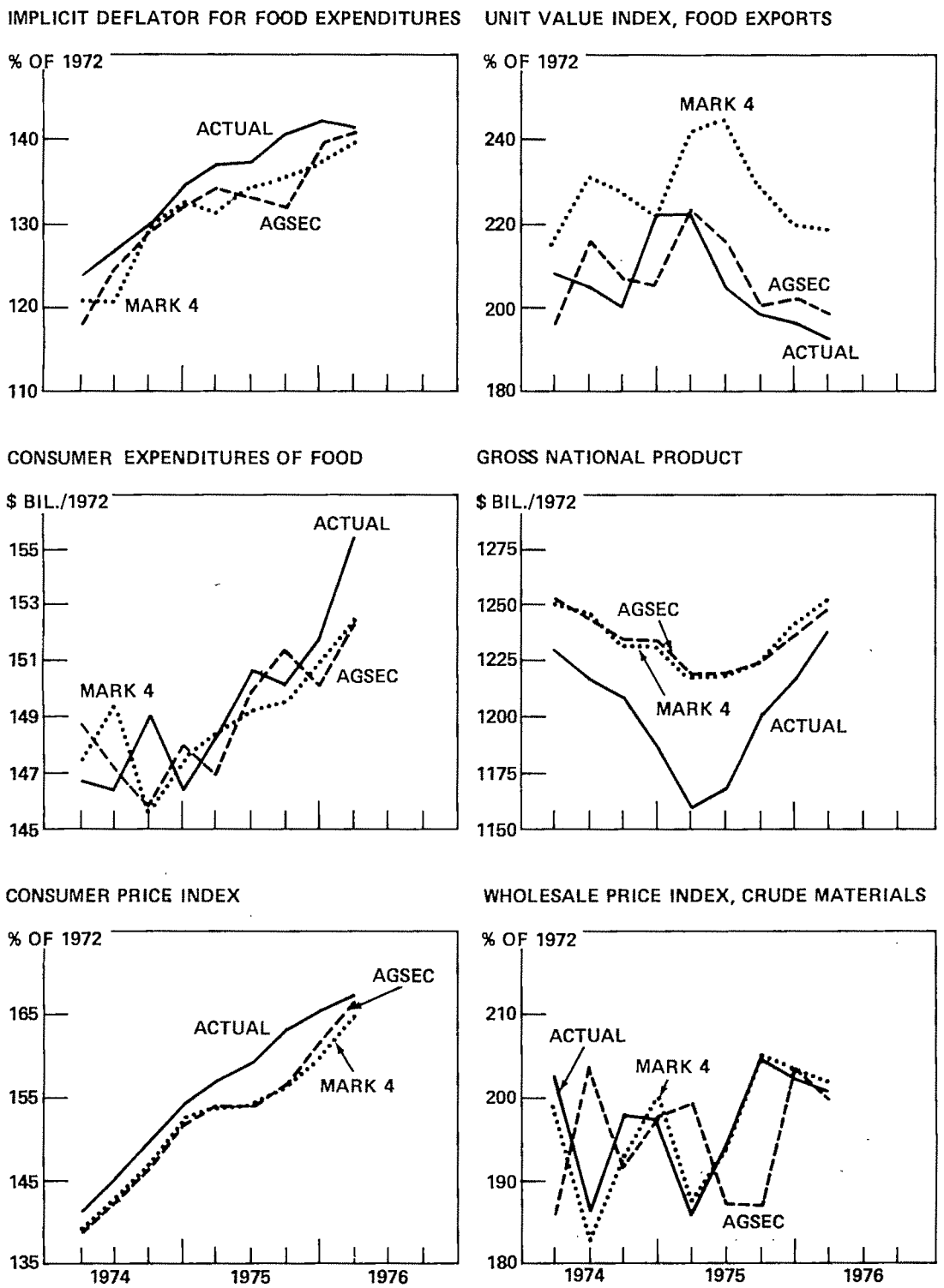


Figure 2. Plots of simulated values for Mark IV, AGSEC, and actual values of selected macroeconomic variables

restructuring the agricultural sector of Mark IV are shown in figure 2. Even a cursory glance at figure 2 suggests that any respecification of the agricultural sector of a large macromodel will considerably alter the results. Even for the consumer price index the

agricultural portion of which is quite small, the alteration of the agricultural sector makes a noticeable difference, though not a large one. In two cases, in the estimation of *CENF* and *PWPC**, AGSEC seems to introduce a systematic one-quarter lag in the direction of change. For the wholesale price index, which is driven by the exogenous variable *PFR** in Mark IV, this systematic lag is understandable since *PFR** is endogenous in AGSEC and exhibits the same one-quarter lag. But for *CENF*, the systematic lag is unexpected. In one case, *PTEEDGF*, the AGSEC augmented model clearly improves its performance considering either levels or direction of change. In the other cases shown in figure 2, the differences suggest that there is little difference in results.

These results suggest that altering a large macroeconomic model by changing the structure of its agricultural sector will have a significant effect on the values predicted by the model. The results at this juncture, however, do not warrant the conclusion that prediction will be improved.

Summary and Conclusions

This paper has demonstrated that an aggregate agricultural sector model can be structured on the basis of the income accounting identities of the farm sector and then embedded into a large macroeconomic model. Simulations and a prediction interval test of the model as a satellite outside the period of fit suggest that specification of the model can be improved. Results of simulating the large macroeconomic model with the embedded agricultural model suggest that some measures of predictive performance are improved, others show little or no change, while others predict with less accuracy.

Throughout this paper we have attempted to refrain from unwarranted statements and conclusions. The ultimate goal of this research is the development of an agricultural sector model based primarily on aggregate data and embedded within a larger macroeconomic model. The purposes of such a model are manifold: it could be used to examine the impact of proposed policies, both agricultural and otherwise, and for short-term forecasting of agricultural aggregates to augment the USDA's current situation and outlook efforts; and it could contribute to knowledge of how agriculture and the rest of the economy affect each other.

The caution arises from a disinclination to have the current model used for any of these purposes. This paper is no more than a status report on this development work. Current plans call for considerable refinement of the model, including disaggregating the farm price and marketing equations to generate cash receipts for, at least, livestock and feed. In addition to this horizontal disaggregation, we plan some vertical disaggregation to better describe the effects of farm market phenomena on wholesale and retail food prices and the effects of agricultural and other exports and imports on the agricultural sector.

We also plan to alter our strategy with respect to the use of the national income accounting identities. We currently accept the change in farm inventories as exogenous. This allows derivation of the real value of agricultural output through identities, thus implying a supply response in real terms that takes little account of the other real variables in the system. We plan to alter this by estimating real output directly allowing inventory changes to adjust in order that the identities be satisfied.

At this point conclusions can only be tentative. They are nonetheless suggestive of at least two things: a macroeconomic model may be substantially altered by a change in what is one of the relatively smaller sectors of the total economy, and the project is feasible, and in our opinion, a promising one.

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Price Determination Processes for Agricultural Sector Models

Dale Heien

Until recently, traditional subsector model analysis for agricultural products had focused largely on supply-acreage considerations. This was particularly true of the crops sector, where historically supply has outstripped demand, leaving market prices at support levels. Supply response equations often used the support price as the supply price, reducing even further the role of market prices. However, the disappearance of excess capacity from agriculture has shifted attention to the demand-price side of the ledger. Recent experience with worldwide grain price inflation and its impact on domestic livestock prices has reinforced the need to consider further the price determination mechanism for agricultural products. Traditional concern with supply response in an environment of excess capacity centered around the farm income problem, i.e., the relative decline of rural America. Analysis of this problem has been the prime concern of agricultural policy makers since the 1930s. On the other hand, high food prices have been the source of recent political concern, not only because of their direct effect on the cost of living but also because of "second-round" inflationary effects due to increased wage demands. These higher wages in turn lead to inflationary pressures of their own in the nonfood sectors of the economy. Hence, price determination is an appropriate topic for a session on econometric models since, as will be shown, the nonfarm economy plays a large role in that process.

Economists, both agricultural and otherwise, have historically paid relatively little attention to the price determination process. For the nonfarm sector, the first serious effort at price modeling came from the Eckstein-Fromm price equation. A simplified version of macro model price behavior is as follows. Demand determines output; the difference between actual and potential output (i.e., unemployment) and lagged prices determine wages; wages and output determine prices. Various refinements of this basic approach are the mainstay of most aggregate models, although some have been revamped with a stage-of-processing model along the lines developed by Popkin.

The price determination process for agricultural models can be summarized as follows. Lagged prices, costs, government programs, weather, and the carryover determine supply; output and price expectations determine stock levels; the difference between stocks and supply is identically equal to demand; demand is determined by prices and income. This yields a system of four equations in four unknowns. Hence, price is determined by the interaction (i.e., the intersection) of supply and demand. This conceptualization places a large burden on the stocks equation in the price determination process. The consequences of this specification, while not readily apparent when examining single equation results one at a time, become evident in complete solutions. Since errors of substantial magnitude are not uncommon in stocks equations, the prices generated in this manner are also subject to considerable error. One obvious answer to this problem is to improve the stocks equation. This is difficult for several reasons. First, ending stocks are typically the entry that balances the supply and utilization tables. Hence, they become the depository for measurement error throughout the system. Second, only a portion of stocks is due to intended, rational behavior on the part of businessmen. Some portion of stocks are unintended accumulation (or depletion), i.e., the difference between supply and demand when the businessmen's desired stocks are added to demand. Third, knowledge of the range of motives for holding stocks and how to model these motives is at best meager.

Dale Heien is a private economic consultant in Washington, D.C.

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The notion of enumerating variables and equations, strongly reinforced by a tradition of linear specifications and matrix solutions, led to a further obscuring of the price determination process. Solution techniques such as the Gauss-Seidel method require normalization. (For a technical discussion of this technique, see Heien, Matthews, and Womack.) For each endogenous variable in the model, there must be a unique structural equation with that variable as the dependent (left-hand-side) variable. The strict interpretation of this requirement is that each variable in any given econometric system has a unique causal structure.[1] This is, of course, a mathematical requirement and as such has no particular economic significance. However, Fisher has given economic interpretation to this requirement by posing the following problem. Assume that all variables in a given model are caused by other variables (in the same system) acting with some time lag, no matter how small, i.e., a causal chain system. This is an extremely plausible assumption. When these relations are aggregated over time (e.g., from days to months or months to years) the resulting system is no longer a causal chain type but is now fully simultaneous. More importantly, it is also a simultaneous model with a unique dependent variable for each equation in the model. Hence, what was a completely recursive system becomes, when aggregated over time, a simultaneous system normalized in the Gauss-Seidel manner.

The importance of this result is that if the notion of lags between cause and effect is accepted, the resulting simultaneous model is normalized in a causative sense. Mere counting of equations and unknowns no longer suffices.[2] This requires a causative specification for each variable in the system including, of course, prices. Acceptance of this notion implies that the traditional supply, demand and stocks specification, is erroneous. One of the equations must be normalized on price. One solution to this problem has been the introduction of the idea of price dependency to the demand relation.

[1] This in no way contradicts the notion of a system of simultaneous (i.e., jointly dependent) equations.

[2] Mere counting of the equations and unknowns, of course, did suffice. It is assumed here that the rank and order conditions are fulfilled.

The Notion of Price Dependency

The idea of price dependent relations goes back to the early foundations of agricultural economics. Sewell Wright in 1921 perceived the causative nature of prices in this sense (Fox). The basic idea underlying this notion is that for most agricultural products total output is predetermined in the short run, due to the role of past prices in the supply relation and the time required for new acreage to be brought into production or for livestock herds to be expanded. With supply virtually predetermined, the only possible variation remaining in the system is either in stocks or price. In the short run, stocks can vary a great deal relative to demand. However, over the period of a year, storage facilities are limited. Hence, stock level variation is also somewhat limited, which is particularly evident when annual stock-consumption ratios are compared with monthly or quarterly ones. Over the course of a year, stock levels, particularly for meats, are relatively stable, implying that prices are determined by the demand for the product in question. At this point the question is which demand—farm or retail? One can use farm level and then arrive at the retail price through the use of a margin equation that relates the retail price to the farm price and other processing costs. This specification is appropriate but in a different context that will be discussed later. Waugh took the position that over long time periods (which is the case here) retail demand was the determining factor and the farm-level demand was a derived demand.

When considering models in an annual framework, the position taken by Waugh is a more fruitful approach and is consistent with the recent theoretical work by Gardner. From a conceptual point of view, the model outlined here is similar to that used by Gardner. However, in order to empirically implement such a model, normalization decisions must be made for each relation. The type of model envisioned here may be specified as follows. The retail food product (P) is a function of the farm product input (F) and, for simplicity, a "bundle" of processing and marketing services (B), or

$$P = g(F, B). \tag{1}$$

Letting the price of a good in question be represented by its lower case letter, the supply relation for the farm product is F

$= g(f_{-1})$. The retail demand may be specified in several ways, which are discussed below. For the present, the retail demand is written as the price dependent relation $p = g\{P^d, z\}$, where P^d is quantity demanded and z is other factors such as income. Converting equation (1) to a supply relation under competitive conditions gives

$$(2) \qquad P^s = g\{(p/f),(p/b)\} \quad \text{and} \quad P^d - P^s = S,$$

where S is stocks, and $S = g\{P^d\}$ so that $P^d = f\{P^s\}$. Under competitive conditions

$$(3) \qquad f/p = g'(F, B).$$

Using equations (2) and (3), the demand for the farm level input can be expressed as

$$(4) \qquad F = g\{(p/f),(p/b)\}.$$

However, noting that F is already determined, equation (4) is inverted to give the price dependent factor demand curve

$$(5) \qquad (f/p) = g\{F,(p/b)\}.$$

If, for example, the production process is given by a Cobb-Douglas production function $P = aF^{\alpha}B^{\beta}$, then the analog for equation (5) is

$$(6) \qquad (f/p) = aF^{-\gamma}(p/b)^{\theta},$$

where $\gamma = (1 - \nu)/(1 - \nu + \alpha)$, $\theta = \beta/(1 - \nu + \alpha)$, and $\nu = \alpha + \beta < 1$. Hence, $\gamma > 0$, $\theta > 0$, and $\partial f/\partial p \cdot p/f = 1 + \theta$. When food prices fall (or rise), they fall (rise) further at the farm level than at the retail level. The above is a possible explanation of this observation. Equation (6) is also the "farm-retail margin." Increases in marketing costs in equation (6) will lower the farmers' share, while decreases in farm level output will increase it. A complete analysis of the margin is only possible through analyzing the complete set of relations, such as was done by Gardner.

Examples of the empirical implementation of these relations are given below for fed heifers and steers and barrows and gilts:[3]

$$(PFEC/RPB) = 23.57 - \underset{\substack{(4.1)\\ 0.12}}{0.20}FBHSS + \underset{\substack{(2.6)\\ 0.23}}{5.72}(RPV/CVBP),$$

$$\bar{R}^2 = 0.77 \quad \text{and} \quad D.W. = 1.46;$$

$$(FPP/RPP) = 8.89 - \underset{\substack{(0.4)\\ 0.09}}{0.052}TNPS - \underset{\substack{(0.8)\\ 0.20}}{9.65}(TNPS/CAP) + \underset{\substack{(5.9)\\ 0.83}}{27.3}(RPP/WRMP) + \underset{\substack{(1.6)\\ 0.38}}{0.162}T,$$

$$\bar{R}^2 = 0.85 \quad \text{and} \quad D.W. = 2.04;$$

where *PFEC* is price of fed cattle, *RPB* is retail price of beef, *FBHSS* is fed beef heifer and steer slaughter, *CVBP* is cost variable for beef processors, *FPP* is farm price of pork, *RPP* is retail price of pork, *TNPS* is total number of pigs slaughtered, *CAP* is capacity in the pork industry, *WRMP* is wage rate meat processing industry, and *T* is a time trend. These relations were fit over the 1950–70 period by ordinary least squares.

The notion of price dependency can also be fruitfully applied at the retail level. The specification of retail demand begins with the theory of the budget of the consumer. The consumer is assumed to maximize a static single period utility function

$$(7) \qquad U = f(q_1, \ldots, q_n)$$

subject to the budget constraint

$$m = \sum_{i=1}^{n} p_i q_i.$$

This maximization process yields the demand relations,

$$(8) \quad q_i = f_i(p_1, \ldots, p_n, m) \text{ for } i = 1, \ldots, n.$$

In view of the homogeneity restriction, these relations may also be written as

$$(9) \quad q_i = f_i(z_1, \ldots, z_n) \qquad \text{for } i = 1, \ldots, n,$$

where $z_i = p_i/m$ and are called normalized prices. Due to the large number of prices and quantities required, the above system is not empirically manageable. (An exception is an

[3] The figures below the coefficients are the *t*-ratios. The figures below the *t*-ratios are the elasticities.

approach such as Frisch's. For empirical implementation of this approach, see Brandow, George and King, and Hassan and Johnson.) Empirical demand analysis, following the theoretical system of Marshall, turned to real-income relative-price system of the form

$$(10) \qquad q_i = \alpha + \beta(p_i/p) + \gamma(y/p),$$

where p is the price of all goods. This system, with various modifications, has formed the basis for the majority of applied demand analysis. Cast in a price dependent form, the above relation is estimated as $(p_i/p) = \alpha/\beta + (1/\beta)q_i - \gamma/\beta(y/p)$, Hence, if $\gamma > 0$ and $\beta < 0$, income increases have a positive effect on the own price. In order to consider the case of substitute goods, equation (10) is written in double-log form:

$$(11) \qquad q_i = \alpha(p_i/p)^{\beta}(p_s/p)^{\theta}(y/p)^{\gamma},$$

where p_s is the price of a close substitute. In order for s to be a substitute, $\theta > -\gamma w_j$. Since the budget share w_j will be quite small ($\simeq 0.03$ for beef), θ may be taken as a positive number. Rearranging equation (11) as a price dependent relation gives

$$(12) \qquad (p_i/p) = \alpha q_i^{1/\beta}(p_s/p)^{-\theta/\beta}(y/p)^{-\gamma/\beta}.$$

From equation (12), for $\gamma > 0$, $(\partial p_i/\partial y)(y/p_i) = -\gamma/\beta > 0$, $(\partial p_i/\partial p_s)(p_s/p_i) = -\theta/\beta > 0$, and $(\partial p_i/\partial p)(p/p_i) = 1 + (\gamma + \theta)/\beta \lesseqgtr 0$. Since it is likely that $|\gamma + \theta| > |\beta|$, it is also likely that $(\partial p_i/\partial p)(p/p_i) < 0$, i.e., increases in the overall price level have a depressing effect on the price of the good in question. The economic explanation is that as the price level increases real income falls, shifting the demand curve downward and causing a fall in price. An increase in the price of a close substitute shifts the demand upward, causing price to rise. This is another way of looking at Hicks' proposition that the prices of close substitutes move together.

One can extend theory of the budget of the consumer in a manner to accommodate the notion of price dependent demand curves while retaining the theoretical rigor of utility analysis. This can be accomplished through the use of what Samuelson has called "mixed" demand systems. Substituting the demand equations given by equation (9) into equation (7) gives

$$(13) \qquad U = f(z_1, \ldots, z_n),$$

or the "indirect" utility function. Minimization of equation (13) subject to $1 = \sum_{i=1}^{n} q_i z_i$ gives the inverse demand equations:

$$(14) \quad z_i = f_i(q_1, \ldots, q_n) \qquad \text{for } i = 1, \ldots, n.$$

In the above system the prices are the variables and the quantities are given, i.e., the opposite of the conventional case. In the mixed system, some of the prices are assumed given. For the remainder of the goods, the quantities are predetermined, or

$$U = f(q_1, \ldots, q_h, \bar{q}_{h+1}, \ldots, \bar{q}_m, \bar{z}_1, \ldots, \bar{z}_h, z_{h+1}, \ldots, z_n).$$

Optimization of the above function yields the mixed demand system

$$q_i = f_i(z_1, \ldots, z_h, q_{h+1}, \ldots, q_n) \qquad \text{for } i = 1, \ldots, h$$

and

$$z_j = f_j(z_1, \ldots, z_h, q_{h+1}, \ldots, q_n) \qquad \text{for } j = h + 1, \ldots, n.$$

As discussed above, the supply and, with relatively fixed stocks, the demand for many agricultural products is given. Applying the mixed demand system to livestock products, for example, the demand for beef, pork, and poultry are assumed to be given as are the prices of all other goods. The resulting demand functions give the normalized price of beef as a function of the quantities of beef, pork, and poultry and the normalized price of all other goods. A set of these mixed demand relations were estimated for beef, pork, and broilers for the U.S. economy using annual data from 1950 to 1970. The results are given in table 1.

With supplies of beef, pork, and poultry relatively inelastic in the short run, the effect of changes in money income (*PCENDS*) and other prices (*PAO*) are the main short-run determinates of meat prices. Table 2 gives the reduced form elasticities for the retail price of pork (*RPP*), beef (*RPB*), and broilers (*RPC*) with respect to *PCENDS*, *PAO*, and real income (*PCENDS/PAO*).[4] Hence, in pe-

[4] The elasticities in table 2 were computed from a livestock

Table 1. Estimates of Mixed Demand Relations for Beef, Broilers, and Pork

Dependent Variable	Constant	*QC*	*QB*	*QP*	*ZAO*	$\bar{R}^2$/D.W.
ZC	5.4	−0.0055	−0.078	−0.004	−3.74	0.98
		(9.1)	(3.0)	(1.0)	(4.4)	1.44
		1.58	0.60	0.74	0.74	
ZB	2.6	−0.0025	−0.0126	0.0015	−1.50	0.96
		(0.7)	(8.6)	(0.7)	(3.2)	1.31
		0.1	1.86	0.16	(1.66)	
ZP	2.6	−0.0146	−0.0037	−0.0101	−1.05	0.92
		(3.8)	(2.2)	(4.2)	(2.0)	1.31
		0.58	0.57	−1.13	−1.20	

Note: *ZC* is retail price index of chicken divided by income, *ZB* is retail price index of beef divided by income, *ZP* is retail price index of pork divided by income, *QC* is per capita consumption of chicken, *QB* is per capita consumption of beef, *QP* is per capita consumption of pork, and *ZAO* is retail price index of all other goods divided by income.

riods of rapidly increasing real income such as 1973, meat prices increase substantially. In the long run the price increases are ameliorated by the increased supply response, which eventually lowers prices. However, short-run spurts in real income give rise to food price increases that have political repercussions. Hence, stabilization of aggregate demand may help to stabilize food prices and avert costly and disruptive price controls.

Estimation of demand curves in the mixed system form also has several advantages from a statistical point of view. First, because they are close substitutes, prices of livestock products tend to move together, creating problems of multicollinearity when demand curves are estimated in the conventional manner. There is less collinearity between the quantities consumed of livestock products, due mainly to differing production cycles. Second, if in fact supply is relatively exogenous and relatively nonstochastic, then most variation occurs in price as it adjusts to clear the market. Hence, the assumption of fixed (nonstochastic) regressors is more closely fulfilled under the mixed specification.

The Notion of Excess Demand

The specification of price determination outlined above was essentially an empirical approach to a static equilibrium model. For annual frameworks, where adjustment lags in price formation can be ignored, the price-dependent notion is satisfactory. However, in quarterly and monthly models some account must be taken of inertia and disequilibrium even in competitive markets. At the heart of the disequilibrium model is the notion that supply and demand are not in balance, which is most widely articulated in the literature on the Phillips curve. The rate of excess demand in any market is defined as supply minus demand divided by supply, or $(S - D)/S$. For the labor market, the rate excess demand is the unemployment rate. The Phillips curve relates the rate of change of money wages to the unemployment rate. Hence, when supply and demand are in balance, wages do not change. Without going into the elaborations and refinements of the Phillips curve, the same approach can be applied to agricultural products. For agricultural commodities the difference between supply and demand is the change in stocks. Take, for example, the Phillips curve for corn,

$$(15) \qquad \dot{PC} = f\{(BSC - ESC)/SC\},$$

where *PC* is the price of corn, *BSC* and *ESC* are beginning and ending stocks, respectively, and *SC* is the supply. Since at the beginning of the crop year, *SC*, *BSC* and PC_{-1} are given, equation (15) becomes

Table 2. Short-Run Reduced Form Elasticities for Retail Prices of Pork, Beef, and Broilers

	PCENDS	*PAO*	*(PCENDS/PAO)*
RPP	2.20	−0.74	0.86
RPB	2.66	−1.66	0.36
RPC	1.74	−0.74	0.87

model that included endogenous (though highly inelastic) supply. For a description of this system, see Heien, Kite, and Matthews.

$$(16) \quad PC = f\{ESC, \overline{BSC}, \overline{SC}, \overline{PC}_{-1}\}.$$

Equation (16) emphasizes the role of stocks in determining grain price. Once planting intentions are known, the main determinant of each fall's supply is weather. As the crop year progresses, more and more information becomes available concerning the total crop. Better data on acreage planted becomes available, as does data on weather (e.g., rainfall at critical stages of crop growth). This information in turn affects the present price in the auction market. Demand information has a similar impact. Knowledge of an unexpected grain sale to Russia will reduce expected carry-over and hence raise grain prices. An example of this approach is

$$PC = \underset{}{0.535} + \underset{(5.6)\ 0.90}{0.945\,PC_{-1}} - \underset{(1.8)\ 0.20}{0.43\,EUSC}$$
$$- \underset{(2.3)\ 0.26}{0.115\,ECSC} + \underset{(1.8)\ 0.20}{0.02T},$$
$$\bar{R}^2 = 0.79 \quad \text{and} \quad D.W. = 1.36,$$

where $EUSC$ and $ECSC$ are ending government and commercial corn stocks, respectively.

The notion of excess demand can also be applied in other ways. For example, the demand for dairy products made from manufacturing grade milk is composed of the demand for butter, frozen products, evaporated and condensed milk, cheese, and dry milk. These can be converted to pounds of milk through known conversion factors and the excess demand approach used. On the other hand, an index of dairy product demand can be computed using some base year demand as weights. The ratio of this index to supply is then a measure of excess demand. An example of such an approach, taken from Heien, is

$$PMGM = \underset{}{-0.46} + \underset{(3.2)\ 0.48}{0.67(LIDPQ/QMGM)}$$
$$+ \underset{(4.1)\ 0.65}{0.66\,PMGM_{-1}},$$
$$\bar{R}^2 = 0.94 \quad \text{and} \quad D.W. = 1.63,$$

where $PMGM$ is price of manufacturing grade milk, $LIDPQ$ is Laspeyres index of dairy products demands, and QMGM is quantity of manufacturing grade milk.

The excess demand notion of price determination is perhaps more consistent with quarterly or monthly observations than the price dependent approach outlined above, since the excess demand notion provides for a disequilibrium framework, whereas the other notion is an empirical implementation of a static equilibrium model. As suggested, stocks can fluctuate considerably in the short run. Price behavior for such situations might be modeled as follows. Short-run farm level demand is determined by the derived demand from the Cobb-Douglas function, or

$$(17) \quad F^d = \alpha Pp/f,$$

while the farm level supply again is given or at least is highly inelastic. Stocks of F are residually determined by the difference between supply and demand for F. The demand for F is driven by the retail demand for P in equation (17), which for this framework would be fit as a standard quantity dependent demand curve, or $P^d = f\{p, z\}$. Hence, in a model of this type, the long-run price behavior would be quite similar to that outlined above. If retail demand shifts as a result of, say, a change in income, farm level demand also rises, perhaps with some small lag. With supply unchanged (no prices have changed), stocks fall, driving up the farm price. This price increase is in time passed on to the retail level through the margin equation. This increased price results in a decrease in demand, which again is passed through the system in the same manner as the original shift.

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Discussion

Stanley R. Johnson

It seems apparent and is well argued by Fox (1973) in a report to the Council of Economic Advisors and the authors of the three papers for this session that public and private economic agents are requiring increasingly integrated and complex models of the agricultural sector for forecasting and decision purposes. Recognition of this unfulfilled demand for modeling of the agricultural sector raises a number of questions that are useful to keep in mind while evaluating the papers of Chen, Roop and Zeitner, and Heien. They are: why is the profession just getting around to formulating, estimating, and implementing such models? What factors have held back the development of these models and can they be identified? Have the authors of these papers addressed and resolved the issues raised by the first two questions?

The answer to the first of the questions can be viewed both positively and negatively. On the positive side, the increased role of government in the agricultural sector and in import and export markets, the increased sophistication of agents operating in the sector, increased flows of information into and within the sector, and finally the complexity and timing problems brought about by more freely flowing resources and added specialization all argue for the development and use of more comprehensive models. On the negative side, the "failures" of past attempts may account for the lag in applying widely known modeling techniques to the agricultural sector. In retrospect, it is apparent that the initial econometric models of the agricultural sector (e.g., Fox (1965), Cromarty) were oversold not so much by their builders but by those applying the methods and concepts that they embodied. One of the peculiarities of the agricultural sector is the high proportion of the variation in endogenous variables that is conditioned on exogenous variables that are difficult to project. As will be subsequently apparent, the overselling of the earlier sectoral models and some shortcomings of the present efforts have resulted from a lack of careful attention to this simple factor in model evaluation. Answers to the latter two questions are, in fact, the subject of the remainder of the discussion and, to anticipate the conclusion, they are qualified yeses.

At a general level, problems raised by attempts to construct these "second generation" models of the agricultural sector are several-fold. Specifically, for evaluating these models it seems reasonable to ask: (*a*) how large and complex should the models be? (*b*) what purposes or functions are served by increasing the complexity and size of the models? (*c*) are the objectives of the potential clients sufficiently similar to make one or a limited number of large-scale sectoral models adequate? (*d*) is the theory adequate to support the specification of these sectoral models? (*e*) are available data sources being used to advantage? (*f*) are the estimation procedures employed making good use of the sample and prior information? (*g*) are the models validated using methods that take best advantage of the theory, previous empirical work, and data? (*h*) is structural change sufficiently accommodated so that models are not highly specialized? (*i*) is there provision for updating the models in a systematic manner? and (*j*) finally, are policy and forecasting exercises being conducted so as to fully exploit the information contained in the models? General comments on these questions, although unduly brief, can provide a useful basis for evaluating the papers.

Regarding questions (*a*) and (*b*), both Chen and Roop and Zeitner have identified forecasting and policy needs but have omitted an important step in the process of rationalizing their larger or more integrated models as superior to existing constructs. Suppose it is agreed that the purpose of such models is to reduce the unexplained variation in an expanded set of exogenous variables. Whether this explanation should be structur-

Stanley R. Johnson is a professor of economics and agricultural economics, University of Missouri-Columbia.

ally oriented or not is left open. What must be shown is that the models link the endogenous to exogenous variables that have substantially less unpredictable variation. Otherwise, the structures have provided little for forecasting and prediction. If the variation in the endogenous and uncontrolled exogenous variables is about the same and the exogenous variables cannot be accurately projected then the structural model is of little value for forecasting purposes (Chow). As the simulations of Chen and Roop and Zeitner are based on assumed values for exogenous variables that would appear difficult to project, they may significantly misrepresent the usefulness of the models for forecasting and as well the claimed validity of the structures for applied policy analysis.

The problem of developing models that can be specialized for a number of diverse purposes deserves more attention than is given in the papers. From a mechanical viewpoint, this task is more straightforward for linear than for nonlinear and complex constructs of the type proposed by Chen and Roop and Zeitner. In this more general context, the idea of building models of the models, albeit a bit esoteric, may be useful. With such a conceptual framework, processes of specializing multipurpose models can become more formalized. In particular, for question (*c*) the same approaches can be applied in the context of specializing the complex models as are used in structuring the relationship between the model and sector. In the systems vernacular, models of systems or sectors are themselves systems. Approaches to their study can thus follow similar lines of inquiry.

Regarding question (*d*), i.e., the theory, there are useful developments that have occurred since the "first generation" models of Fox (1965) and Cromarty. In fact, Heien's paper seems to address this point. His suggestions for applying mixed demand systems rationalized on the basis of inverse utility functions and behaviorally determined storage components exemplify areas in which the theory has developed potential for additionally structuring sectoral models. Uncertainty and risk (Just), price expectations formulations versus observed futures prices, firm dynamics (Lucas), and dynamic consumer behavior (Philps) are additional areas in which the developments in theory seem not to have been advantageously used in providing structure for econometric models of the agricultural sector. Finally, for the linkages between the agricultural sector and economy, it is not apparent that much progress has been made. Providing these links with a series of identities is possible and done by Chen and Roop and Zeitner, but there must be more to the connection between economic sectors of an economy. Much the same is true of the provision for imports and exports. For the latter the lack of a more elaborate structure leaves as exogenous variables ones that have proved very difficult to project.

On the use of the data (question (*e*)), the authors of the two applied papers have been disappointingly unimaginative. In fact, in both papers much is made of the models being developed so as not to require data unavailable in generally known sources. Prior information, subjective or not, weighting observations, and combinations of time series and cross section and annual and quarterly series are all possibilities for gains in information to be captured in the estimated sectoral models. For example, the wealth of experimental data on crop production could support much more ambitious structures for relating weather variables to supply response (McQuigg). The practical objectives of both models to an extent explain this conservative treatment of the data. Apparently, some improvements in model quality can be obtained by working these alternative data sources. As well, such activities provide information on the potential value of additional but unavailable quarterly series.

Estimation procedures used by Chen, Roop and Zeitner, and Heien are not the most sophisticated. The arguments made for the use of single-equation ordinary least squares procedures are, however, for the present compelling; that is, the authors have decided to use their scarce resources for model construction and data assembly rather than estimation, which is consistent with the observation that the major gains to be made in sectoral modeling are in specification. When the anticipated returns to specification diminish, applications of improved estimation methods should be explored for their contribution to model performance. Among those not presently being applied, the biased estimation methods (Judge) and, of course, simultaneous equations methods seem most promising.

Simulation and/or experimentation with

the models is usually involved in both validation (question (*g*)) exercises and in forecasting and policy analysis (question (*j*)). Here, the standards in most applied modeling work in agricultural economics and not just those of Chen and Roop and Zeitner are notably lacking. Moreover, the procedures tend to be mechanically applied and not systematically evaluated (Rausser and Johnson). Weakness of the mean square error of forecast is an obvious case in point. Presumably this statistic is useful in evaluating the model for forecasting, but is the forecaster ever in the position to know the future values of exogenous variables with certainty? The answer is, of course, no. Although the test is of some use for observations on the structure, it can lead to undue enthusiasm about the validity of models and their potential value in a forecasting context.

Finally, there are considerations of structural changes (question (*h*)) and updating (question (*i*)), where there is ample room for improving the current sectoral models. Available results making the provision for variational parameters (Rosenberg), updating (Chow), and more flexible tests for structural change (Singh et al.) are readily applicable in the context of the presently specified sectoral models. These sectoral models are obviously nothing more than partial reduced forms for highly complex economic systems. Accordingly, it is important to specify them so that they can be continually revised to comply with information contained in most recent observations generated by the agricultural sector.

More specialized observations on the papers can also be made. The model presented by Chen is impressive in terms of its sheer size. Although a full development of the specification was not (and given space limitations could not have been) available in the paper, the summary information given shows that the model is producing at least intuitively acceptable results in some areas. The care and effort involved this process should not be over looked or undervalued. What has been provided is a workable quarterly econometric model of the agricultural sector that is highly disaggregated and can be integrated with the Wharton model of the general economy.

Specification and estimation procedures used in the model are standard or not significantly in advance of those employed by Fox over ten years ago. As a consequence, there is room for improvement of the model in each of the aspects suggested by aforementioned questions. For example, Chen cites Popkins' work on average prediction errors but does not demonstrate that his model moves toward their reduction in a systematic way. Almon lags are employed instead of time structures, which might be argued on a more sound theoretical basis. Linkages to general economy differ from those of Roop and Zeitner but are similar in being largely based on a set of accounting-type identities. Data are limited to those available on a routine basis, and little attention is given the problems of updating and structural change. The latter problems are, however, implicitly involved in the choice of the length of the data series to be used in estimating and testing the model. More positively, the linkages between subsectors, their commodity orientation, and the inclusion of climatic variables in the supply equations all speak well for a keen insights as to the workings of the agricultural sector.

The paper by Roop and Zeitner is more a progress report than a completed research project. A sectoral model, which is much more limited than that of Chen and does not perform well on a satellite basis even in limited validation exercises, is specified and then introduced into the Wharton model of the general economy. The linkage to the general economy model is again accomplished by a system of identities decomposing the aggregates in the present version of the agricultural sector. While the problem to which the paper is addressed is one that should receive attention and, in defense of the authors, is quite difficult, it is only fair to say that there is not evidence of much progress. A sectoral model that performed more acceptably on a satellite basis could have enhanced the value of the results of its integration with the model of the general economy.

Heien's paper is interesting in that it seems to be trying to get at the problem of specifying sectoral or commodity models to take more advantage of the available theory. As one who has had a hand in constructing the large-scale Commodity Economics Division/Economic Research Service cross-commodity agricultural sectoral model, his paper can be construed as evidencing a dissatisfaction with the standard structural specification. The concern with the treatment of stocks is

justified, and the approach providing a behaviorally enriched structure for explaining stocks holding is promising. What it suggests, however, is the need for more fully exploiting the results from dynamic models. The production function approach to relating retail and farm demands is not novel but is very adeptly explored for its implications in price relationships. As already indicated, the comments on mixed demand functions should receive substantial attention. They provide a consistent theoretical basis for formulations of demand functions that in the past have been specified by data dredging. Finally, the reference to Fisher and casual structures may need further elaboration. Although the principle is of use, the period of observation and level of aggregation for sectoral models make the result more of aesthetic than practical value.

In summary, it is encouraging to observe and be a part of the rekindling of interest in sectoral econometric models. The general and specialized comments pointing up the limitations of these papers should not be taken to be reflections on the work of the authors but instead to be encouraging possibilities for progress. These papers have provided a useful basis from which to proceed in improving the second generation sectoral models.

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Agricultural Sector Models and Their Interface with the General Economy: Discussion

Richard E. Just

Chen points out that macroeconometric forecasters have done very poorly in predicting inflation rates, etc., for the general economy because they have failed to predict changes in their exogenous prices, many of which pertain to the agricultural sector. However, agricultural forecasters have also done very poorly in predicting the recent large variations in agricultural prices, and again the reasons lie in the lack of inclusion or difficulty in prediction of exogenous variables, some of which pertain to the general economy. Thus, both general and agricultural forecasters may benefit by pooling their models.

In a sense, the above arguments indicate that the predictive power of econometric models may be increased by increasing endogeneity. The notion is plausible because, as exogenous variables are converted to endogenous ones, the econometrician is forced to identify more basic underlying forces, which may lead to more useful predictions. This argument further suggests that the dynamic predictive performance of an econometric model in tracking certain variables should be evaluated not only in terms of the standard statistics, such as the root-mean-square error, but also according to the degree of endogeneity of the model from which they are generated. If one continually "plugs in" values of a closely related but simultaneously determined variable throughout the period of simulation for another variable, then the predictive performance should obviously be much better than if closely related variables are also determined endogenously. The latter approach is also often more sensible for predictive purposes, since measurements for simultaneously determined variables are not available in applied forecasting situations.

Richard E. Just is an assistant professor in the Department of Agricultural and Resource Economics, University of California, Berkeley.

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Before discussing the three papers of this session in this context, it is necessary to consider first what is an appropriate degree of endogeneity? Which variables in the general economy are determined simultaneously with or as a result of variables in the agricultural economy and vice versa? How important are these simultaneous or feedback relationships?

Interaction Between the Farm and Nonfarm Sectors

The interface between the agricultural sector and the general economy includes at least three classes of relationships: (*a*) the interaction of general price and income levels, agricultural marketing costs, and agricultural prices in domestic demand for agricultural products; (*b*) the interaction of agricultural input markets, which are influenced by other economic sectors, with the supply side of the agricultural sector; and (*c*) the interaction of international trade in agricultural and nonagricultural goods in determining trade balances, exchange rates, and export demand. Traditionally, agricultural sector models have emphasized mainly the first class of relationships and to a limited extent the second. The third class of relationships has been almost universally ignored.

The paper by Heien, which provides a nice summary of many classical causal and theoretical arguments in agricultural models, typifies the traditional approach (at least in those parts of his paper that deal with the interface of agricultural and general econometric models). General price and income levels and marketing costs are considered, but the supply and trade interfaces with the general economy are disregarded. The degree of endogeneity in the econometric models

produced by Heien is, indeed, very low.[1] For example, the farm-retail price spread for hogs and cattle is explained by using retail price as an exogenous variable.[2] Economic theory, however, indicates a high degree of simultaneity between farm and retail prices, and both can easily be treated endogenously in the same model. In his later regressions of retail beef, pork, and chicken prices on consumption of beef, pork, and chicken (Heien, table 1), a great deal more endogeneity is possible and perhaps necessary. Within the mixed demand system approach Heien uses, the specifications of his equations imply that consumption of all three commodities are determined prior to the corresponding prices. This possibility certainly seems unlikely, and exactly the reverse seems to hold on a day-to-day basis in grocery stores.

Turning to the Roop and Zeitner paper, one finds the second class of interface relationships relating to supply of agricultural inputs is also included. Hence, a feedback relationship is completed by linking both the input and output sides of the agricultural sector to the Wharton Mark IV econometric model of the general economy. However, the third class of interface relationships relating to international trade is absent. In fact, agricultural exports are apparently not considered endogenously by Roop and Zeitner at all. Such a practice may have been acceptable prior to the 1970s, but recent events too clearly point to the importance of trade and export demand in agricultural price determination. Although Roop and Zeitner's discussion suggests that "farm prices received enter directly into the determination of the unit value index of food exports," recent developments imply that a more likely possibility is exactly the opposite—export demand and prices have been a major determinant of farm prices received or the two are determined simultaneously. Roop and Zeitner, in fact, admit their lack of confidence "that the important interactions between the agricultural sector and the macroeconomy are being captured."

Roop and Zeitner conclude that agriculture "is one of the relatively smaller sectors of the total economy." If this is true, then one can argue that there is no simultaneity or feedback between agriculture and the general economy; hence, an interface is only important from the standpoint of including general economic variables exogenously in the agriculture sector. Both of the other papers in this session argue that this is not true and that agriculture does have an important impact on the general economy. Based on their arguments and the ones developed below, one must at least conclude that Roop and Zeitner's assertion is unwarranted, since their model specification precludes many of the economic relationships that lead to a strong impact of agriculture on the general economy.

Interaction of Agricultural and Nonagricultural Sectors Through Trade

Before proceeding further, a brief review of some of the events of the early 1970s may be useful. In this context, one can suggest ways in which agricultural, as well as general econometric models, have tended to be inadequate, especially in the interface.

Never before has this country experienced the kind of instability, in both agricultural and nonagricultural sectors, that it has in the last five years. Prices of some agricultural commodities like wheat, corn, and soybeans have more than tripled from 1971 to 1974 and have since fallen by about half that amount (Commodity Research Bureau). This tremendous volatility in U.S. agriculture has almost certainly been tied to international trade, as evidenced by the large increase in Soviet demand for U.S. grain. Initially, these huge price increases were attributed to production shortfalls and rising affluency in the world as a whole and, particularly, in the Soviet Union. But later Schuh advanced the hypothesis that currency realignment (exchange rate) was largely responsible for increased U.S. grain demand. Certainly, both variables (prices and exchange rates) made unprecedented movements almost simultaneously. The U.S. exchange rate (dollars per special drawing right [SDR]), which had been stable for twenty years, increased by about 25% from 1971 to 1974 and then declined again by about 10% (International Monetary

[1] I recognize that Heien may be merely intending to suggest functional forms, which could be imbedded in larger econometric models with greater endogeneity.

[2] One must also question this procedure on grounds of econometric theory since, if retail price is stochastic, the regression disturbance would be correlated with the independent variable, retail price. In this case, Heien's estimation methods produce biased and inconsistent estimators.

Fund). Schuh further argued that "exchange rate has been an important omitted variable" in U.S. agriculture models (p. 11). His hypothesis has since been tested in an econometric model for U.S. wheat specifically designed for that purpose, and the results overwhelmingly support Schuh's arguments rather than the production or income explanations (Fletcher and Just).[3] The exchange rates were treated exogenously in carrying out this test.

In the context of this discussion, the Chen paper is to be commended. He has developed a model that considers all three classes of interface relationships with the general economy. Both input and output linkages to the agricultural sector are provided, but also the impact of exchange rates enters in export demand equations for agricultural crops. Furthermore, much greater commodity detail is provided, the simultaneity within agriculture is much more explicitly included, the interaction of the feed and livestock sectors is clearly indicated, and government program variables are included in more detail and with more usefulness for policy-making purposes. Chen's arguments for commodity and intertemporal disaggregation are indeed sensible. The Roop and Zeitner paper is evidence supporting Chen's statement that "because of the gap existing between the complexities of farm commodity markets and the simplified nature of the agricultural sector specification in macromodels, little can be expected." Even in a model with much greater endogeneity, Chen's root-mean-square errors are generally lower than Roop and Zeitner's.

In view of the title of this session, however, it is appropriate to consider yet a further generalization in the interface of agricultural and general models. The three agricultural commodities mentioned above, for which prices more than tripled (while exports soared), represented three of the five most important commodities (in value terms) in U.S. international trade as of 1974 (Commodity Research Bureau). Furthermore, these three commodities are almost exclusively export items while the other two commodities (crude petroleum and iron-steel) were primarily import items. Of course, trade theory would indicate that when major export items are rapidly increasing in value, *ceteris paribus*, an extreme pressure is placed on trade balances, and eventually exchange rates must be adjusted to alleviate the pressure. As exchange rates are adjusted, domestic prices of many other internationally traded items, such as imported automobiles, also begin to change. Hence, the recent large variations in agricultural exports may have played a major role in the high rate of inflation in the general economy not just through the resulting high domestic food prices but through the international trade interface with the general economy. For a possible example, following roughly the same pattern as agricultural trade and general exchange rates, some steel prices more than quadrupled from 1971 to 1974 and then declined to about twice their 1971 levels (Commodity Research Bureau). This casual evidence is not at all conclusive. The true causal relationships may run in either direction or simultaneously in both directions. But at least these arguments suggest the possibility of some interesting and badly needed experiments relating to the interface of agricultural and general econometric models and the importance of agriculture in determining U.S. trade balances and exchange rates.

U.S. exchange rates have now been deregulated for more than two years, and they have been to some extent determined by trade conditions since 1971, when exchange rates began responding to balance-of-trade pressures. It seems that an endogenization of exchange rates in agricultural models or in the overall models in which they are imbedded is now appropriate, particularly given the importance of agricultural commodities in U.S. trade. But such a step requires that we go far beyond the usual level of interfacing agriculture with the general economy. Appropriate possibilities must also be allowed for interaction of the agricultural sector with other commodities not only domestically but also in determining trade balances and ex-

[3] Although there have been several attempts to show that exchange rates cannot possibly explain more than about a 25% movement in prices because exchange rates only moved by about 25%, such conclusions are not warranted in a more general model. If one considers that currency realignment is more closely akin to changing national income (e.g., changing purchasing power for all traded goods) rather than a simple price change for the commodity of interest, then in a model with several commodities both real price and quantity demanded for import (of a single good) may increase simultaneously purely as a result of exchange rate adjustment. Since this argument will be a topic of discussion in another paper, it will not be pursued further here. Even though Chen considers exchange rates, his model does not allow this possibility since exchange rates are used only to modify the price of the specific good(s) in question.

change rates, as well as the related feedback impact of exchange rates on export demand.

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Research on the Economics of Household Consumption Behavior
(Rueben Buse, University of Wisconsin, Chairman)

Cross-Section Application of Linear Expenditure Systems: Responses to Sociodemographic Effects

Howard Howe

Analysis of consumption allocation with expenditure systems is well known in aggregate, time-series applications. Yet, until recently, studies of individual household behavior have not generally brought available demand theory to bear on the empirical estimates. Pollak and Wales cited two advantages of using complete demand systems for the study of demographic effects on consumption. Demand systems incorporate the budget constraint into the analysis and permit the separation of demographic effects from own- and cross-price effects as well as from income effects. Unless these effects are separated, the demographic effects estimated with one set of prices cannot be presumed to apply in a different price situation.

This paper discusses the interpretation of linear Engel curves as reduced forms of the linear expenditure system (LES) and the extended linear expenditure system (ELES). Parameters of these systems can be made functions of the sociodemographic characteristics of the household. With constant prices, the marginal budget shares in the LES are identified, but the subsistence expenditures are not. The ELES, which uses income in place of total expenditure, is exactly identified; all its parameters can be estimated by indirect least squares. Subject to the assumption of additive separability underlying the LES and the savings behavior implicit in the ELES, price effects can be estimated with data from a single cross section.

Howard Howe is an economist in the International Finance Division, Board of Governors of the Federal Reserve System.

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Linear Expenditure System

Properties

The demand functions of the LES can be written

$$(1) \qquad x_{ih} = b_i + \frac{a_i}{p_i}\left(\mu_h - \sum_{k=1}^{n} p_k b_k\right) \quad \text{for } i = 1, \ldots, n,$$

where x_i and p_i are the quantity and price, respectively, of good i, and μ_h is the total expenditure of household h. Klein and Rubin developed the LES as the most general linear formulation in prices and income satisfying homogeneity, the budget constraint, and Slutsky symmetry. These demand functions represent the utility function

$$(2) \quad U(X) = \sum_{k=1}^{n} a_k \ln(x_k - b_k), \qquad a_i > 0, \sum a_k = 1, x_i - b_i > 0.$$

The a_i's are marginal budget shares, and the b_i's have been interpreted as a "necessary" or "committed" set of goods. Pollak cautioned, however, that strict interpretation of b_i as a necessary level of consumption could be misleading because b_i can take on negative values. The utility function is defined wherever $x_i - b_i$ is positive. The admission of $b_i < 0$ permits price-elastic goods.

The Stone-Geary utility function, as equa-

tion (2) is known, underlying the LES is additive and nonhomothetic. The additivity permits price responses to be expressed in terms of the subsistence quantities (or expenditures). The nonhomotheticity introduced by the subsistence quantities allows the LES to exhibit nonunitary expenditure elasticities.

Sociodemographic Effects

In cross-section studies, the sample is often subclassified by sociodemographic characteristics of the household to reduce unexplained variation in expenditure behavior, and Engel curves are estimated separately for these subsamples. Another means of taking sociodemographic effects into account is to postulate that parameters of the expenditure system are functions of household characteristics.[1] Pollak and Wales have described this procedure as "translating" the demand system.

The "subsistence quantity" of the LES (b_i) can be made an explicit function of the sociodemographic characteristics of the household such as age, education, occupation, number of members, etc. For simplicity, b_i is postulated to be a linear combination of these effects. Let

$$(3) \qquad b_{ih} = \sum_{g=1}^{m} c_{ig} z_{gh},$$

where c_{ig} is the effect of the gth characteristic on the subsistence quantity for good i and z_{gh} is either a dummy variable or a quantitative variable.

In principle, the marginal budget shares (a_i) could also be made functions of household characteristics: $a_{ih} = \sum_{g=1}^{m} \alpha_{ih} z_{gh}$. This generalization complicates the formulation because the LES requires $\sum a_k = 1$. The marginal budget shares would have to be divided by $\sum_{k=1}^{n} \sum_{g=1}^{m} \alpha_{kg} z_{gh}$ because there is no single scale factor that could be applied across all observations. In the studies reported here, a_i was treated as constant across households; only b_i was made a function of household size.

[1] Barten incorporated household composition effects using specific adult equivalent scales. Muellbauer expanded this approach using the indirect utility function. When considering the LES, Muellbauer obtained the same result as equation (5).

Expenditure Equations and Engel Curves

In a single cross section, it is assumed that all households face identical prices. The demand functions, equation (1), can be written in expenditure form

$$(4) \quad p_i x_{ih} \equiv e_{ih} = p_i b_{ih} + a_i(\mu_h - \sum_{k=1}^{n} b_{kh} p_k) \qquad \text{for } i = 1, 2, \ldots, n,$$

where the subscript h on b_i indicates that subsistence quantities now vary across households. Introducing equation (3) and defining $\gamma_{ig} \equiv p_i c_{ig}$, the expenditure equation becomes

$$(5) \qquad e_{ih} = \sum_{g=1}^{m} \gamma_{ig} z_{gh} + a_i(\mu_h - \sum_{k=1}^{n} \sum_{g=1}^{m} \gamma_{kg} z_{gh}),$$

where γ_{ig} is the value (at sample prices) of the gth characteristic's contribution to the subsistence expenditure of good i.

The reduced form of equation (5) is a linear Engel curve

$$(6) \qquad e_{ih} = \sum_{g=1}^{m} \delta_{ig} z_{gh} + a_i \mu_h,$$

where, by comparison with equation (5), δ_{ig} is implicitly defined as

$$(7) \qquad \delta_{ig} \equiv \gamma_{ig} - a_i \sum_{k=1}^{n} \gamma_{kg}.$$

As evident in equation (6), the marginal budget shares are all identified. The subsistence expenditures γ_{ig} cannot be recovered from the δ_{ig} because the system is underidentified by degree 1. Additional information or restrictions are required to permit identification of the γ_{ig} and thereby the inference of price effects.

Extended Linear Expenditure System

Lluch developed the ELES from an intertemporal maximization of the Stone-Geary utility function, equation (2) (1973). The ELES employs (a concept of permanent) income as the explanatory variable and incorporates an

aggregate consumption function. The typical ELES expenditure equation is written

$$(8)\quad e_{ih} = p_i b_{ih} + ma_i(\zeta_h - \sum_{k=1}^{n} p_k b_{kh}) \qquad \text{for } i = 1, \ldots, n,$$

where m is the marginal propensity to consume and ζ is permanent income.

The ELES is a particularly useful generalization of the LES in cross-section applications in that the independence of income from the expenditure error terms overcomes the least-squares bias encountered using total expenditure and that the ELES permits indirect least-squares estimation of all parameters since it is exactly identified.[2] The ELES can be developed from an atemporal utility maximization by treating saving as the $(n + 1)$th commodity, with $b_{n+1} = 0$ (Howe 1975). This a priori specification of one of the b's identifies the remaining subsistence expenditures in the absence of price variation.

The alternative development of the ELES can be repeated using current income (y) in the budget constraint instead of permanent income (ζ). In this case saving is out of current income, and m becomes the marginal propensity to consume current income. Using the same formulation for modifying the subsistence expenditures as with the LES, equation (3) can be substituted into equation (8) to obtain ELES functions reflecting the sociodemographic characteristics of the household. The current income version is

$$(9)\quad e_{ih} = \sum_{g=1}^{m} \gamma_{ig} z_{gh} + ma_i(y_h - \sum_{k=1}^{n} \sum_{g=1}^{m} \gamma_{kg} z_{gh}).$$

The reduced form of equation (9) is an Engel curve based on income

$$(10)\quad e_{ih} = \sum_{g=1}^{m} \Delta_{ig} z_{gh} + \eta_i y_h.$$

The marginal propensity to consume (m) equals $\sum \eta_k$. The marginal budget shares are then obtained from $a_i = \eta_i/m$. The γ's are identified from the Δ_{ig} and η_i.

The γ_{ig} identified in this way are subsistence expenditures at sample prices rather than the subsistence quantities themselves of equation (3). Strictly speaking, the c_{ig} that would appear in the structural ELES equation (9) are not identified. As Powell pointed out, measurements on p_i at the time of the sample are sufficient to identify the quantities. Price elasticities are readily expressed in terms of the subsistence expenditure; quantities are not required to evaluate price responses.[3]

Cross-section Estimates of Linear Systems

Prior to the introduction of the ELES, Betancourt applied the labor-leisure choice and wage rate information to the LES to estimate total subsistence expenditure and thereby identify all parameters (1971). Belandria employed the LES and the ELES to analyze cross-section household consumption data for three Venezuelan cities. He showed that the LES is underidentified where prices are constant over the sample and that the ELES is identified under the same conditions. Belandria treated the parameters of the expenditure systems as constant across households. Subsequently, Powell systematized Belandria's results on cross-section application and integrated them with new results on large sample biases in LES estimates.

In the following review of LES and ELES cross-section applications, the first two sets of studies translate the demand system with respect to household size or composition. The third group of studies follows the more conventional procedure of estimating the systems separately for demographically similar subsamples.

Estimates of Household Composition Effects

In an application of LES and ELES to Colombian cross-section data for 1967–68, Howe emphasized the effects of household composition on expenditure (1974). Following equation (3), the subsistence quantities

[2] Transitory components of current income could be correlated with the error terms of certain expenditure items. The use of normal income as a function of socioeconomic variables amounts to an instrumental variables procedure and results in unbiased estimates.

[3] The own-price elasticity can be expressed as $\epsilon_i = (p_i b_i/p_i x_i) \cdot (1 - a_i)^{-1}$ and the cross-price elasticity can be written in the form $\epsilon_{ij} = -a_i(p_j b_j/p_i x_i)$.

were postulated to be linear combinations of the number of persons in each of three age classes: zero to seven years, eight to seventeen years, and over seventeen years, and z_1 was set to 1 to represent the head of the household.

Estimates of the ELES parameters of equation (9) were obtained by indirect least squares and compared for four cities. Table 1 presents ELES estimates (and their standard errors) for Bogotá. The estimates of the marginal budget shares and the marginal propensity to consume out of current income are reasonable. The negative values for $\hat{\gamma}_{ig}$ are not easily interpreted in terms of subsistence expenditure, but none of the negative values are significantly different from zero. Also, the income effects are estimated with much greater precision than the subsistence expenditures.

Interestingly, the significant subsistence expenditures are all for persons aged eight to seventeen years and over seventeen years. It could well be that, at this level of aggregation, children under seven years of age simply do not affect consumption allocation greatly or consistently enough across income levels to yield significant γ's. In interpreting the subsistence expenditure of the head of household, it is useful to recall its role as an intercept term; its insignificance could reflect the lack of a constant term (or nonlinearity near the origin). In retrospect, a better formulation for subsistence quantity could have been

$$b_{ih} = c_{io} + \sum_{g=1}^{3} c_{ig} z_{gh}, \tag{11}$$

where the head would be counted as a member of the over seventeen years class, and the intercept could be tested explicitly.

Table 1. ELES System Parameters, Bogotá

		Subsistence Expenditure ($\hat{\gamma}_{ig}$)[a]			
	$\hat{a}_i$	P 0–7	P 8–17	P 17+	Head
Food	0.3742	85	384	809	130
	(0.0077)	(75)	(68)	(86)	(239)
Shelter	0.2720	−49	217	541	81
	(0.0058)	(54)	(49)	(62)	(172)
Clothing	0.1020	−8	76	170	−10
	(0.0021)	(20)	(18)	(27)	(65)
Medical	0.0350	0	21	49	5
	(0.0007)	(8)	(3)	(10)	(28)
Durables	0.0350	−15	35	55	−3
	(0.0007)	(12)	(11)	(35)	(39)
Transportation	0.0316	3	29	61	0
	(0.0006)	(5)	(6)	(7)	(21)
Miscellaneous	0.1402	−35	153	268	−103
	(0.0028)	(27)	(24)	(31)	(86)
MPC($\hat{m}$)	0.8482				
	(0.0166)				

[a] Colombian pesos per quarter at 1967–68 prices.

Nutritional Information

Just as the a priori specification of $b_{n+1} = 0$ for saving permits identification of the ELES in the cross section, independent information on any other subsistence expenditure identifies the remaining γ's of the LES. The use of nutritional requirements to estimate subsistence expenditures on food was inspired by Orshansky's work on defining the poverty line in the United States.[4]

For the Colombian study, independent measures of the minimum cost diets necessary to maintain adequate nutrition for persons of various ages were obtained. Monetary values of the minimum cost diets at prices prevailing during the sample period were used as extraneous estimates of the subsistence expenditure for food.[5] The resulting LES estimates are presented in table 2.

The estimated marginal budget shares of the two systems are very close. The subsistence expenditures for ages eight to seventeen years and over seventeen groups are within two standard deviations of the $\hat{\gamma}$'s estimated with the ELES. The $\hat{\gamma}$'s for the head of household are very different, a result of the intercept problem discussed above. The $\hat{\gamma}$'s for children under seven years old are much larger than those in table 1.

The poor estimates of γ for children obtained with ELES are probably a result of very different expenditure responses to children across income strata. Use of dummies for socioeconomic stratum in equation (3) for intercept and interactive effects would be the next step in improving the estimates of γ with the ELES.

[4] In an attempt to count the number of persons living in poverty in the United States, Orshansky observed that "there is no generally accepted standard of adequacy for essentials of living except food" (p. 5). She then proceeded to use low-cost food plans of the U.S. Department of Agriculture as the minimum outlays necessary to maintain adequate nutrition. The food plans are tailored to the age-sex composition of the household.

[5] A poverty budget approach was also tested in the Colombian study. The poverty budget for the individual household was substituted for the "subsistence expenditure" $\sum \sum \gamma_{kg} z_{gh}$ in equation (5), thus identifying the individual γ_{ig}. However, the estimates of γ_{ig} for food were not constrained to equal the values of the minimum cost diets.

Table 2. LES System Parameters Identified with Extraneous Nutritional Information, Bogotá

		Subsistence Expenditure ($\hat{\gamma}_{i0}$)[a]			
	$\hat{a}_i$	P 0–7	P 8–17	P 17+	Head
Food	0.3965 (0.0070)	[291][b]	[480]	[750]	[750]
Shelter	0.2797 (0.0074)	99	298	463	576
Clothing	0.0994 (0.0038)	47	100	148	138
Medical	0.0294 (0.0027)	13	29	37	48
Durables	0.0342 (0.0032)	15	31	38	54
Transportation	0.0319 (0.0025)	18	39	52	59
Miscellaneous	0.1290 (0.0040)	33	176	216	125

[a] Colombian pesos per quarter at 1967–68 prices.
[b] Values of minimum cost diets.

Economies of Scale

The linearity assumption of equation (3) was relaxed by redefining z_{gh} as a dummy variable for each size of household from two members to eleven or more. Although this modification lost the distinction between children and adults, it allowed subsistence expenditure to vary nonlinearly with household size. The profiles of the $\hat{\gamma}$'s as a function of size exhibited puzzling declines at five, eight, and eleven or more members. For the subsistence interpretation of the γ's to hold, subsistence expenditure must at least be increasing with respect to size of household.

These anomolous results are probably due to the same lack of consideration of socioeconomic stratum that caused problems with the household composition effects. With further refinement, this procedure could be useful in studying economies of scale in household expenditure. Ferber and Musgrove plotted the general trend of these estimates of food and total subsistence expenditure by household size. They found elasticities of subsistence expenditure with respect to size close to 1.0 for the range three to eleven or more persons.

Other studies investigated household size effects in translated linear expenditure systems without distinguishing household composition. Howe and Musgrove applied the ELES to four Latin American cities—Bogotá, Caracas, Guayaquil, and Lima—making only the distinction between large (five or more) and small households. The systems were also estimated separately by (*ex ante*) socioeconomic stratum (three strata approximating permanent income levels) and age of head (under forty-five years and over forty-five).

Committed expenditures (γ) tended to be larger for higher stratum households, showing that the γ more nearly represent subsistence needs at low incomes, while habits and expectations become more important as income rises. Younger households tended to have lower mean expenditures but higher committed spending. They behaved as if their notion of a minimally acceptable standard of living, or their expectations about future income, was higher than that of older households. The difference between γ_i (large) and γ_j (small) was greater for young than for old households.

Estimates of the marginal propensity to consume were extremely varied and often too low. They did not always decline as socioeconomic level went up, and they were often low for very low income households.

Separate estimation by stratum overcomes a major criticism of linear systems—the constancy of marginal budget shares across income levels, but it may complicate the study of household saving. If the share of income variation due to permanent income is not constant across strata, the bias in estimating the marginal propensity to consume due to transitory elements may be made worse when the sample is stratified (Howe and Musgrove). This problem was more serious with young than with old households.

Betancourt applied current income (1976) and permanent income (1973) versions of the ELES to Chilean data for 1964. He reformulated the ELES to use discrete time and a finite horizon and allowed subsistence expenditure to vary as a function of household size with an economies-of-scale effect. The ELES was then estimated separately by twelve subsamples (six age classes and urban-rural location). Shift dummy variables for occupation (also interpreted as socioeconomic class) were applied to income and household size.

Betancourt found that, although failure to control for socioeconomic stratum led to differences of less than 10% in the income-related estimates of ELES, differences of substantially greater than 10% resulted in the price-related ELES estimates (1976). Esti-

mates of the economies-of-scale parameter varied widely.

Pollak and Wales applied two cross-section data sets to obtain price variation for estimating the LES and a quadratic expenditure system. They used family expenditure data from the United Kingdom for 1966 and 1972. Mean consumption expenditures on three categories for twenty-nine cells of various income and family size classifications were combined with price indexes for the two periods. The subsistence quantities were translated as functions of the number of children in the household. The estimation employed the same methods used for time-series data with price variation. Although not the first to pool cross-section data, Pollak and Wales demonstrated that sufficient price variation existed in only two cross sections to permit identification of the parameters.[6]

Estimation by Subsample

In addition to the studies presented above that also incorporated variable subsistence expenditures, three recent cross-section studies investigated the influences of sociodemographic characteristics with separate estimates by subsample using constant subsistence expenditures. Lluch, Powell, and Williams (chaps. 5, 6, and 9) estimated the ELES for Korea, Mexico, and Yugoslavia.

For Korea, urban-rural differences in demand behavior were explored by estimating the ELES separately for urban and farm households. Per capita income and expenditure data from annual sample surveys were combined with consumer price indexes for each of these areas. Then urban cross-section data for 1971 were separated into six subsamples (salary and wage earners, young and old head of household, small and large household), and separate ELES estimates were obtained for each type of household. The authors show that for expenditures on nondurables, the cross-section data yielded disaggregated demand parameters and elasticities that, when averaged, were broadly consistent with time-series estimates.

For Mexico, separate ELES estimates were obtained for thirty-two subsamples (rural-urban location, socioeconomic class (3), large and small family, young and old head of household) of the population surveyed in 1968. The authors found that if the data were to be pooled for estimation, the model should allow for family size effects, the subsistence parameters should shift by socioeconomic class, and marginal budget shares should be allowed to vary with income. The first two modifications could be accomplished in a translated ELES using the form of equation (3).

Separate ELES estimates were applied to twelve subcells of Yugoslavian farm households separated by region and type of farm. Income levels varied substantially across these groups; mean income more than doubled from poorest to richest. Marginal budget shares showed little variation by income level. Although the farm households were reasonably homogeneous with respect to demand behavior, savings behavior was influenced by income level.

Income Concepts for the ELES

All of the results reported thus far proceeded from an ELES using current income. As developed theoretically, the ELES employs a concept of permanent income. In an attempt to develop a measure of permanent income, Belandria estimated relationships between current income and age, education, and occupation. The estimated coefficients were then used to impute expected or normal income for each household.

Howe employed the same procedure to generate a measure of normal income except that the log of income was used as the dependent variable (1974). Betancourt applied a method whereby the household in question is assumed to focus upon a similar household in the next highest age class to form an estimate of its permanent income (1973).

Howe found that although the normal income ELES provided superior estimates of the marginal propensity to consume for two of the four cities, the number of observations for which subsistence expenditure exceeded actual expenditure (a violation of the LES property, equation (2)) was much greater than with current income (1974, pp.201–13). Belandria and Betancourt also found that normal or permanent income produced significantly higher estimates of the γ's. Because the normal income procedures underestimate the variance of permanent income,

[6] Lluch used price variations among regions to estimate an LES with cross-section data from Spain (1971).

current income has been preferred for estimation of the ELES.

Conclusions

Modest success has been achieved in estimating price effects along with income and sociodemographic effects from cross-section data. Although such estimates are obtained at the cost of very restrictive assumptions, the results have often been reasonable enough to encourage further application to cross-section data. The ELES could prove particularly useful in developing economies where sufficiently long time-series data on the components of consumption are lacking.

Although the LES and ELES provide wide scope for analyzing a single cross-section of household data, some caveats are in order. Aside from the restrictiveness of the LES itself, the complications arising from transitory behavior in the cross section are considerable. Because of the severity of the assumptions, the ELES parameter estimates could be valid only locally. Care should be exercised in extrapolating the system far from the sample prices and incomes.

Both translated expenditure systems and separate systems by subsample are applicable to policy-oriented models. Since the translated models discussed here all varied subsistence expenditures while holding the MBS and MPC constant, estimation by subsample could be a useful first step in testing the validity of that assumption. A translated system is superior to a set of subsystems in that it imposes the budget constraint on the analysis of sociodemographic responses. A translated system requires that the changes in expenditure components in response to a change in household composition sum to zero if total expenditure remains constant.

In all of the studies reported here, separation into subsamples was employed to some extent. Even in the Colombian study, with the most extensively pooled model, estimation was separated by city. In most cases, all parameters of the system differed significantly by subsample.

A rule of thumb for applying demand systems to policy problems would be to incorporate the sociodemographic effects to be analyzed (age distribution, household size or composition, etc.) in the translation of the system and then to subdivide the sample by the other sociodemographic characteristics known to affect importantly the parameters of the system. In this way the restrictions of demand theory are imposed on the effects under study, while unexplained variation in expenditure behavior resulting from other sociodemographic differences is reduced. However, as found in Howe and Musgrove, stratification of the population may improve the expenditure functions but lead to unreliable descriptions of savings behavior. Another aspect of such a procedure requiring careful judgment is that the number of subclasses could proliferate to the point of making sample sizes too small and simulation of the full system unwieldly.

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Household Consumption Behavior: Understanding, Measurement, and Applications in Policy-Oriented Research

Alden C. Manchester

I am interested in understanding consumer behavior for use in policy-oriented research. In pursuit of this goal, the possible assistance of theory to better understand consumer behavior is discussed, and empirical measurement of the parameters of consumer behavior is considered in relation to the needs of policy makers.

Theory and Its Uses

Phrases commonly used by economists often tell more about our intellectual habits than is realized. One such phrase is "received theory," which carries the connotation that theory has been received from on high, perhaps inscribed on a new tablet, and the empirical analyst merely takes the theory as provided and proceeds with his analysis. Such a practice is to be avoided in many cases but especially so in the area of household consumption behavior. The analyst should approach the choice of the theoretical constructs at least as carefully as he would the selection of statistical methodology, with due consideration for its effectiveness in the role contemplated.

Measures of what consumers do and of why they do those things are needed. The why's must be in terms of observable phenomena in order to be useful to the analyst, as theory that cannot be put into measurable forms is not useful.

The basic postulate of the economic theory of consumer behavior is that the individual maximizes the utility derived from the consumption of goods and services within a set of constraints imposed by prices and income.[1] The usefulness of this assumption as a basis for organizing the measurement process is somewhat limited since one is unable to suggest a basis for quantifying utility. This inability has one distinct advantage. Since there exists no principle comparable to the principle of profit maximization in firm theory, one is not distracted by the spurious intellectual appeal of the idea or led to the assumption that the rational economic man maximizes a measurable quantity, therefore proving any other behavior to be irrational and intellectually if not morally wrong. The hurdle that must be leaped to explain the tremendous variety in consumer behavior is not nearly as great as that encountered when dealing with firm behavior. It is easier to search for a theory that explains the nonconformity of consumers' behaviors under similar circumstances rather than one that asserts that they should conform. Consumers are no more optimizers or maximizers than are business firms. (This discussion is also in the spirit of Leibenstein.) To a very considerable extent, they are satisficers. Optimization is simply unworkable.

A further difficulty of conventional theory arises from the complication that the household is the consuming unit rather than the individual, which is the basis of the theory. While this probably does not create as much of a problem as the assumption that the entrepreneur is the business firm, even if the firm is General Motors, it is one more reason why a theory based on individual preferences is likely to be unsatisfactory.

Alden C. Manchester is a program leader in Consumer Economics and Demand Analysis, National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture.

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[1] Porter's point that the consumer maximizes net utility (net of the costs of information acquisition measured in utility terms) is appealing but leads no further in terms of empirically usable theory. It merely adds to the measurement problem.

The theory of consumer behavior is constructed in terms of equilibrium concepts, consisting largely of statics or comparative statics. With statistical and econometric investigations strongly conditioned by the theory, a high proportion assume that equilibrium is the general case and that departures from it are taken care of in the error term.

Equilibrium is much less commonly the case than many of us have assumed. For these purposes only major departures from equilibrium are discussed; otherwise, everyone is constantly in disequilibrium. The sources of disequilibrium can be conveniently grouped as economic and demographic. (I ignore for this purpose disequilibrium resulting from psychological sources, such as a major change in lifestyle and purchasing habits). Some of the major economic causes of disequilibrium include change of job, unemployment, reemployment, retirement, strike, purchase or sale of home, change in tenure status, and change of residence (moving). Major demographic changes include marriage, divorce, death in the family, birth, children leaving home, son or daughter off to college, and other relatives moving in or out.

Several recent investigations provide some indications of the incidence of these conditions that lead to disequilibrium. Buse and Salathe, working on a cooperative agreement with the Economic Research Service and using the 1960–61 Consumer Expenditures Survey, excluded 6,300 out of nearly 14,000 records in order to isolate an equilibrium set. They excluded the categories listed above as well as those with missing and obviously wrong data and certain categories that, while in equilibrium, are in a different one than the standard set of households. This last group includes those working without pay, families consisting of husband, wife, and other adults, those continuously retired, nonhousekeeping households, and those who rent rooms.

The University of Michigan study of income dynamics traced an original sample of 5,000 households for five years (Morgan). The changes in those households over the period were mind boggling.

It is obvious from these two studies that the incidence of disequilibrium is quite high and must become a major consideration in concepts and measurement. In measurement, it can be dealt with as Buse and Salathe have by separating out those in disequilibrium and treating them separately, expecting to find different relationships among the variables. Clearly, studies of the adjustment process itself are needed, which can only be done with longitudinal data such as that from Michigan (Benus, Kmenta, and Shapiro).

Applications

The reason for attempting to understand household consumption behavior to make measurement possible—over and above the scientific desire for pursuit of truth—is the application in further research. There are many different research environments. The ERS's interests are in the markets for agricultural products, primarily food and textiles. The demands for these products must be understood to be able to forecast future courses of prices under given (or forecast) supply conditions and to analyze the impacts of a wide variety of policy changes.

In this kind of analytical atmosphere, why are we interested in micro data such as that from cross-section or panel studies? Why are we not satisfied with the aggregate data available from the National Income Accounts, ERS per capita consumption data, and similar sources? The answer has dual roots. In the first place, we are always interested in better estimation of aggregate effects. The aggregates, even if they were perfectly measured, which they are not, mask many changes by the groups that make up the whole. Knowing how different groups within the population behave and the changing relative importance of those groups enables provision of better forecasts. Second, we are interested in distributional effects of economic developments and policy changes, which can be obtained only with disaggregated models.

Some reasons for differential behavior on the part of different groups in the population have already been touched on in the discussion of equilibrium. With appropriately disaggregated models and projections of demographic data, it would be possible to improve forecasts over those that assume average effects for all members of the population.

The basic question is how do households allocate their available resources among various expenditure categories? This is probably a bad way of expressing the question. It seems doubtful that most consumers engage in a process described by economists as

allocation of resources. But the use of the term resources has one clear advantage over using income. It avoids the implication that the expenditures of an individual household are limited by the size of current income. Clearly, the availability of credit and its use change the picture considerably.

What economists seek are the analytical links between the macro variables of the economy—income, price levels, population, and unemployment—and the demand for specific classes of agricultural products. Analyses using aggregate economic measures provide price and income elasticities and a few very crude measures of cross elasticities but not shifters for the demand functions relating to other variables, which are too often assumed away in the *ceteris paribus* assumptions.

The behavior to be understood is that of groups of households, not individuals. The advantage of having data for individual households is that one can search for groupings for which behavior is explainable.

Demographics

Demographic changes are some of the most significant and best documented in the U.S. society. While the approach to zero population growth is probably the most discussed, it is of less current importance than the very rapid change in household size in recent years. Average household size declined nearly 12% from 1960 to 1975 and over 6% from 1970 to 1975.

The growth in one- and two-person households is the most significant portion of this change. This has two major components: the increase in the elderly living alone and the increase in young people living separately from their parents. Both of these in part result from increasing incomes; both have some effect on food expenditures, since one- and two-person households tend to eat out more than larger households and since certain economies of scale in food purchasing and preparation are foregone.

Some preliminary exploration of the effects of demographic variables on aggregate at-home food expenditures has been undertaken (Manchester 1976). The effects of changes in prices, quantities, household composition, and the shift to more or less foods on per capita expenditures for at-home food were estimated for each year, 1960–74. While price changes were the most important, the effects of changes in household composition were more important than the effects of changes in quantity in half the years. Away-from-home food expenditures increased nearly 9% between 1960 and 1975 due solely to the increasing proportion of small households, if the relationships in the 1972–73 Consumer Expenditures Survey diary data are true (U.S Dep. Labor).

The changing age-sex distribution of the population may have greater effects than household size on consumption and demand. A major bulge—the result of the postwar baby boom—is working its way through the population. Since children, teenagers, and adults appear to have considerably different food needs and consumption habits, fairly marked effects have already been seen on the consumption of individual food products (Le Bovit, Schrimper). For a number of food groups, changes in household size and the age-sex distribution "explain" a significant portion of the changes in per capita consumption between 1965 and 1975.

Lifestyles and Attitudes

Changing lifestyles are less well documented than demographic changes for obvious reasons. Purchasing and consumption behavior is, of course, heavily conditioned by the common base of information and attitudes conveyed by the media, principally television. In a society with a dominant middle-class lifestyle, the potential utility of searching out differences in lifestyles as a classification variable in analyses of consumption and expenditure behavior seems small. On the other hand, changes in the dominant lifestyle over time have obvious effects on consumption behavior. The changes in the clothing market in recent years provide an excellent example. The boom in casual clothing reflects the same change in lifestyles as the rapid growth in fast food establishments.

Over time the attitudes and preferences of consumers change, and their purchase patterns reflect this. A major part of these changes occurs in response to the demand creation efforts of manufacturers of food products. The ubiquity of new product development among food manufacturers is well known and is not reiterated here. It is one of

those cases where it is easy to lose sight of the forest by concentrating on the trees. The overall effects of the introduction of new processed food products on purchase patterns tend to get exaggerated by too much concentration on the process. Despite what is known about the massive introduction of convenience foods since World War II, the overall effects on food consumption patterns are minimal. In the nearly two decades between 1952 and 1971, the share of highly manufactured products of total food consumption was virtually unchanged (Manchester 1973). The biggest changes in the whole picture were a sharp increase in fresh meat and a modest decline in fresh fruits and vegetables and eggs.

The dramatic price rises of 1973–75 brought about some marked changes in consumer attitudes and behavior. Consumers say, when surveyed, that they have made fairly significant changes in their purchasing patterns. When the data become available, it will be interesting to see how much change has come about in the aggregate purchase patterns. Whatever the magnitude of change in the last few years, the fundamental question is: will these changes persist as consumers adjust to the changed price levels?

Another significant change is the increase in working wives. This combines elements of demographic change, some change in lifestyles, and changes in attitudes. Cross-section survey data provide an excellent opportunity to analyze the impact of the working wife on expenditure patterns for food and other goods and services.

Kind of Income

The mix of income sources has changed fairly substantially during the postwar period, especially in the last fifteen years. The war on poverty brought a dramatic increase in the number and size of income assistance programs, making significant changes in the kinds of income available to households.

Different kinds of income have different effects on the ways that households use the financial resources available to them. The categorical programs, such as food stamps, have the most obvious effects. Others probably work more through the effect on uncertainty and the willingness to spend a larger proportion of current income and to commit more of anticipated income through the use of credit. The effects on food expenditures are probably mostly indirect through the impacts on other expenditures, but they are all a part of the question of how households allocate the resources available to them. Again, cross-section data provide an opportunity to improve understanding of the effects of different kinds of income on spending patterns.

Diet and Health

Health problems have marked impacts on food purchases. Over half the households in a national probability sample report one or more members with a health problem. Most common was overweight in 30% of the households, with allergies and high blood pressure each reported in about 20% of the households. For most health problems, 50% to 60% of the households had changed diet. This is a potential area for analysis of the effects on consumer purchase behavior. To the extent that health problems are associated with the changing age structure of the population, they are already at least partially covered by consideration of age itself. As new diet-health relationships are hypothesized or identified, impacts on other food groups may begin to be felt. As many other developments, it will be necessary to keep a sense of perspective. Cholesterol and eggs are a good example. Surely, some significant part of the long-term decline in egg consumption is due to changes in habits (lifestyles?) and not due entirely to cholesterol consciousness.

Quality, Services, and Prices

The goods and services for which expenditures are measured are interrelated, as each commodity or good purchased includes certain services and similarly, but not so commonly recognized, many services also include goods. For example, hospital charges include the cost of meals. In addition to variations in the services purchased along with the goods, there are variations in the physical characteristics of many goods that are often interpreted as quality differences. Many times the prices charged for goods include varying amounts for both services and quality differences.

Any data set involves the aggregation of

more than one item; otherwise, the 5,000 items in a typical supermarket would have to be analyzed separately. Whenever items are aggregated within a store and then across stores and cities, various goods, services, and qualities are combined. The necessity of such aggregation is not an excuse for ignoring its consequences.

A small amount of research has been done in looking at some of the variations in service, quality, and price (Houthakker; Manchester, Brown, and Jarvesoo). The basic hypothesis is that the price paid for a given item by an individual household is a measure of its demand for quality and services. In cross-section surveys where quantity data or price data are available, analyses of this type need to be carried out. Aside from the intrinsic interest in the question, separating the effect of quality and service from those of quantity changes will allow the analyst to use expenditure data as a proxy for quantity data with substantially more confidence in the results. As a practical matter, in most cases it is unknown what errors may be introduced into analyses by assuming that expenditures and quantities are identical.

Relevance to Policy Questions

Within the broad field of food and agricultural policy, the number of policy questions that call for analyses in which demand parameters are crucial is legion. No attempt is made here to compile a complete list.

Better estimates of price and income elasticities are needed. In order to derive them, measurements of what are called "shifters" arising out of demographic, economic, and lifestyle changes are needed, both for the aggregate and for significant subgroups of the population. Measurements of the time spans involved in the adjustment process are also required, so that the impacts of proposed policy changes over time can be estimated.

A major area of policy analysis in the ERS deals with changes in commodity programs for crops and milk and their impacts on farm prices, farm income, consumer prices, and government costs. These analyses require farm-level demand functions. Another area, which has been honored more in the breach than in the observance, is marketing services. Despite excellent work a number of years ago (Waldorf), analyses of the demand for processing and marketing services have been neglected. The substantial efforts devoted to measurement of price spreads have been complemented by relatively modest efforts at measurement of relationships between prices at various market levels (Sun, Barr and Blanciforti, Popkin, Manchester 1962).

A rapidly growing area in recent years has been impact analyses. Starting with environmental regulations on costs, prices, incomes, and related variables, this has grown into a major area. Inflationary impact statements are now required by a presidential executive order for a wide range of administrative actions. Several proposals are before the Congress to require cost-benefit analyses for every regulation issued by the Executive Branch and for every legislative proposal sent to Congress. If anything similar to these bills was to be passed, which is likely, the present cottage industry devoted to the preparation of impact statements would develop into a major employer and demander of supply and demand coefficients.

One area that is particularly demanding for good measurements of consumer demand behavior is the analysis of domestic food programs. The food stamp program, the school lunch program, and related food aid programs account for more than a half of the USDA's budget, yet the knowledge base for analyses of these programs is severely limited. Demand parameters relating specifically to food program participants are virtually nonexistent. Their development awaits provision of an adequate data base. Specific parameters that are badly needed include those relating participation in the food stamp program to eligibility.

Conclusion

To summarize, better demand parameters are needed for use in forecasting and policy analysis. The parameters available are unsatisfactory because current understanding of consumption behavior leaves much to be desired. This understanding fails the test of the marketplace because the theory available is imperfect, the means of converting theoretical constructs to observable (quantifiable) behavior is lacking, and the empirical analyses have concentrated on price, quantity, income, and population to the exclusion of

the many other variables that affect demand.

As I recall John Kenneth Galbraith said on a similar occasion, though it would probably not appear so to him, these are all important problems and I recognize that I should have given you the answers. However, you will have to be satisfied with understanding the problem.

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Consumer Expenditure Survey, 1972–73: Processing and Dissemination

Stephen Baer

The Bureau of Labor Statistics (BLS) over the past eighteen months has been publishing tabulated results from the 1972–73 Consumer Expenditure Survey. This paper briefly describes the survey, reports on the status of the dissemination of data in publications and tapes, and discusses some of the factors research analysts must consider as they plan projects that make use of the data. A description of the survey is contained in an article by Carlson.

The Survey

The 1972–73 survey, the eighth in a series and the first in twelve years, is the only comprehensive source of detailed information on family expenditures and income related to socioeconomic and demographic characteristics of U.S. families. These data are also a primary source of information to update the expenditure weights and pricing samples leading to a revision of the *Consumer Price Index* (CPI). The revised CPI is planned for publication in April 1977. The July 1974 issue of the *Monthly Labor Review* contains an article on this subject by Shiskin.

The survey consists of two components, each with its own collection vehicle and sample: a diary or recordkeeping survey completed by respondents for two one-week periods and a quarterly interview panel survey in which families reported information to interviewers every three months over a fifteen-month period. The diary survey was conducted from July 1972 to June 1974. The quarterly interview survey was conducted for the calendar years 1972 and 1973.

The survey design was tailored so that information on larger expenditures was collected by interviewer-assisted periodic recall methods and information on frequently purchased less expensive items was collected by diary recordkeeping techniques. Furthermore, the interview design took account of the notion that some expenditures are easily recalled over long periods, while others are more accurately recalled only over short periods.

Although the diary was designed to obtain the detailed information on food purchases as well as housekeeping supplies, nonprescription drugs and medical supplies, and personal care products and services, respondents were requested to report all purchases made each week except those incurred while on trips.

The quarterly interview survey obtained detailed information on family income, changes in assets and liabilities, and major items of expense. Included was information on housing, utilities, house furnishings, housing repairs and maintenance, clothing, major and minor equipment items, auto purchases, leasing, and repairs, recreation, personal insurance, medical care, education, reading, tobacco, and miscellaneous expenses. Global estimates of food purchases both for at home consumption and at restaurants were also obtained. A comprehensive set of family characteristic information for each family supplemented the expenditure data in each survey component.

The diary sample was divided equally into fifty-two weekly subsamples for each of the twelve-month collection periods. This permitted an accounting for the seasonal nature of expenditures over time. The interview survey samples were initiated in the first calendar quarter of each year. Data collection was conducted over five quarters.

The 1972–73 survey was the first in which the Bureau of the Census took an active part in the collection of the data. The value of its participation is reflected in the cooperation

Stephen Baer is with the Bureau of Labor Statistics, U.S. Department of Labor.

rates attained. The first year diary survey experienced an 80% response rate, growing to 90% for the second year. Over 20,000 one-week diaries were completed each year. In both years of the quarterly interview survey, cooperation rates exceeded 90%, resulting in 10,000 completed questionnaires in each year.

In addition to the collection of data, the Census Bureau was responsible for field editing, quality control, diary coding, production of weights from BLS specifications, data keypunching, and certain computer edits including separation of consumption expenses from business expenses. Tapes of edited data by quarters were transmitted to the BLS at the conclusion of these activities.

Data Processing

The design of the survey has influenced the processing activities and plans for dissemination and creates the need for users to be familiar with concepts and definitions before applying the information to analytic uses. Data from the diary survey were coded by the Census Bureau field staff. Over 1,700 separate item codes were used. Consistency checks were performed to assure that characteristic codes for information such as age, sex, race, etc., were assigned. At the conclusion of data coding and review, information was keypunched and subjected to computer edit. Computer files of the survey information were produced and transmitted to the BLS, where the tapes were further screened for consistency and for valid codes.

The reliance on respondent-recorded entries in the diary led to the need for disaggregation of combined reports in that survey. In some cases, respondents did not supply sufficient detail necessary to meet desired specifications. Item allocation routines were developed by BLS to assign proportions of the value reported for a combined entry among the components of that entry. For the most part, these assignments were made using proportions derived from specific reports in the other completed diaries. For example, nonspecific reports of cheese purchases were allocated among soft or semisoft cheese, solid or hard cheese, or cheese spreads.

Initial pretabulations of data were produced by expenditure code to disclose extreme values. These were cross-referenced with the schedule reports, and updates were performed. Extreme values confirmed as correct were not adjusted. Because of the large volume of diary expenditure reports, only a limited number of tolerance updates could be carried out. These were sufficient to ensure the reasonableness of the resulting publication tables; however, users of final microdata tapes should be careful to inspect the values because of the possible existence of undetected keypunch errors.

Test tables of expenditure data classified by important family characteristics were produced, and separate frequency distributions of individual item codes by characteristics were run. The test tables were reviewed for reasonableness. The weighted frequency counts of socioeconomic characteristics were checked against comparably defined data from the Current Population Series reports (U.S. Dep. Commerce). These evaluations led to further correction of keypunch errors in the income data and program correction in the assignment of family characteristic codes.

The pretabulations were further reviewed for the statistical reliability of mean expenditures. This review helped to determine the level of detail for publication. In the publication tables, the number of sample families in certain columns and cells is small, since the tables present finely classified breakdowns of families and purchases. Column totals based on fewer than seventy sample families or cells containing fewer than five sample observations are likely to have large sampling errors. When these circumstances exist, they are referenced by footnotes to the tables.

Income data were carefully inspected for completeness. While no imputation was conducted, incomplete income reports were identified and coded. The value of income reports from major sources such as wages and salaries and income from profession, unincorporated business, or farm was cross-referenced with reports of weeks worked by each family member. Families were coded as incomplete reporters if the head reported weeks worked but failed to report income from such employment. For cases in which the family head did not work, the procedure was applied to the spouse or other family members. A number of diaries contained members, all of whom did not work during the income reference period. These, most typically, were small families with retired

heads. In such cases, incomplete income codes were assigned if families reported receiving pension, annuity, or social security income but did not provide dollar reports for these income items. Similarly, those families reporting no work experience but indicating receipt of nonemployment income such as welfare benefits or alimony payments were coded as incomplete income respondents if no values for such items were reported. Publication tables by income class contain a separate column of data for families defined as incomplete income reporters. These represent about 11% of the usable diaries. Apparently, many respondents who provided poor or no income data also provided scanty expenditure data.

The collection design for the quarterly interview component specified differing recall periods for various classes of items. Data on income, assets and liabilities, and housing expenditures were collected annually. Data on large expenditures such as major appliances were collected at six-month intervals. Frequently purchased items were collected each quarter. Some information for food and transportation services was obtained by weekly or monthly expense pattern estimates in selected quarters. Data for utilities were collected by quarter from reports on specific bills together with billing periods of reference. These collection procedures were designed to assist the respondents in supplying accurate reports but later introduced computational problems for data tabulations representing a uniform period.

The Census Bureau had the primary responsibility for initial processing of the interview survey data. The family characteristic components for each family record were screened for coding completeness. The expenditure data were subjected to computer adjustments to separate the business portions of expense entries from the consumption portion. These were most typically found in the housing, transportation, and trips components. Also, computer edits were performed to derive missing information in the liability section of the questionnaire. Furthermore, the Census Bureau supplied special nonresponse codes in expenditure fields for which purchases were indicated but no expenditure data were reported. This was possible because most expenditure entries were preceded by conditional yes-no questions. For example, in the collection of clothing data, respondents were first asked whether or not they incurred an expense for an item before being asked for the expense itself. A special nonresponse code was entered if the respondent reported making a purchase but failed to subsequently provide the cost.

Final tapes of the edited and coded data were then transmitted to the BLS. At this stage, special codes were created for data classification purposes. For example, family size codes were produced from the family member data. Programs were written to arrange the expenditure data into desired expenditure classes for publication. Tolerance listings were produced to expose keying errors or questionable reports of great magnitude. Because of the enormous volume of data, only limited tolerance error updates could be undertaken. These have helped to assure the reasonableness of published tabulations, but because not all extreme values were inspected errors may exist on the microdata tapes. Ultimate users of the tapes should carefully review the data for unusual reports.

Procedures similar to those performed for the diary were carried out for the coding of incomplete income reports in the interview. Only about 5% of the usable interview sample of families were identified as being incomplete income reporters. The difference between the 11% incidence of incomplete income reports in the diary and the 5% in the interview is most probably accounted for by the fact that the latter survey benefitted from interviewer rapport built up during the collection of less sensitive data over the four interview quarters prior to collection of income information. The diary, having a minimum of interviewer participation and a short collection period, was not so advantaged.

Data imputation routines were developed by BLS to account for missing expenditure entries using the special Census Bureau nonresponse codes. Regression testing yielded information on those characteristics most likely to explain expenditure behavior. The schedule returns were arrayed on a matrix defined by family income level, tenure arrangements, a family size-type variable, and a geographic variable. Schedules with missing expenditure entries were then subjected to a computer routine in which imputation values were obtained from similarly classified survey families reporting complete information. As might be expected, item nonresponse differed according to the sensitiveness of the

queries. The procedure was useful, but surprisingly few imputations were necessary.

The last major processing step for the interview survey was to convert the data obtained by the various recall collection periods to annual estimates. At the same time, estimates of sales taxes were produced for the expenditure items. This was an extensive and complicated program. At the conclusion of the data review and processing operations, a set of tabulations was produced that was reviewed for reasonableness and statistical reliability.

Dissemination of Results

To date, the Bureau of Labor Statistics has made data available in publications through the Consumer Expenditure Survey series of reports. Data from the diary component of the survey have been published for each twelve-month survey period in selected one-way classifications and cross-classifications of family characteristics. Broad classes of expenditures are shown in these tables. By early 1977 data from both years of the diary survey will be combined and published by family characteristics for the United States and each of four U.S. regions. These tables will present details within broad expenditure classes. The BLS also plans to publish expenditure variances, which can be associated with the magnitude of average expenditures for major consumption components and the number of families represented by the expenditure components.

Work is under way to produce a public-use tape of the detailed diary income and expenditure data in micro form. Included will be wide range of socio-economic characteristics for each diary record and those expenditures for which the diary was designed. Separate tapes covering each twelve-month survey period will be available for sale by the end of 1976. Expenditure components and detail on the tapes will be limited to that which will be published in the combined year reports.

Limited data from the quarterly interview component of the survey have appeared in two reports thus far (U.S. Dep. Labor 1976a, b). Information on vehicle purchase and repair expenses by selected family characteristics for 1972 and 1973 were published in November 1975 (U.S. Dep. Labor 1976a).

Additional selected data on food, tobacco, utilities, house furnishings and equipment, clothing, transportation, reading, education, and gifts and contributions classified by selected family characteristics were published for 1972 and 1973. Expenditures are presented as weighted averages of all sample families represented by the table column characteristics, regardless of whether or not each family reported a particular expense. The mean expenditures of those families actually making purchases can be derived by dividing the weighted sample mean by the percentage of families reporting the purchase. For example, BLS Report 455-1 indicates that U.S. families spent on the average $323.70 on the purchase of new domestically produced automobiles in 1972 (U.S. Dep. Labor 1976a). However, only 9.16% of U.S. families made such purchases. They spent on the average $3,534. Work is continuing to supplement this report with tabulations to appear soon, which will include expenditure data on the above components plus housing, home repairs and maintenance, household operations, alcoholic beverages, health care, selected personal care expenses, recreation, and insurance. Thus, all the components covered by the interview survey will be available soon, but not all the detail for each component. These reports contain what is called summary tables and will cover the periods 1972 and 1973. More detailed tables are planned for next year.

Microdata public-use tapes similar to those for the diary but containing the summary information from the interview component are planned for release in early 1977. These tapes combine selected characteristics with all expenditures reported in the interview survey aggregated to the items shown in the tables.

To recapitulate, neither the diary nor the interview covers the total range of consumption expenditures. The interview covers 90% of them, including global data on food purchases, alcoholic beverages, and tobacco. Three expense components—housekeeping supplies, personal care products, and nonprescription drugs—are not asked at all. A few other expense components in the interview have small pieces missing; for instance, the telephone component contains no data for coin telephone calls.

Problems in Integrating Survey Components

In order to provide a complete account of all expenditures, it is necessary to integrate data

from the two survey components. The Bureau of Labor Statistics plans to do this in publications of data to become available early next year but does not plan to integrate at the microlevel because of the lack of a generally acceptable methodology to accomplish this. Thus, there will be no integrated tapes. Users will have to make their own decisions about data matching and merging techniques. Therefore, it is important to call attention to the types of problems that have to be addressed before undertaking integration.

Plans originally called for the diary to be initiated concurrently with the interview survey. However, because of the lateness in receiving results of diary pretests and the initial burden of interview survey data collection on the Census Bureau's interviewing staff, the diary was not fielded until late June 1972.

The major problem for integration is this difference in the time period coverage between the two survey components, the interview covering annual expenditures for the periods 1972 and 1973 and the diary providing weekly expenditure data for the twenty-four-month period, July 1972 through June 1974.

There is one time period that holds potential for integration—calendar year 1973. Appropriate weeks from each year of the diary can be converted to estimates for 1973. While the collection periods for the two components overlap for the eighteen-month span, July 1972 through December 1973, because of the variable length recall periods in the interview survey, integration over this period is not possible.

Those wishing to integrate on a 1973 basis must address and solve a number of conceptual problems. Income estimates from the second-year interview survey refer specifically to the calendar year 1973 period, but this is not the case with respect to the diary. Diary panel families sampled in calendar year 1973 reported their income for the twelve-month period prior to the week paneled. For example, a diary respondent paneled in January 1973 provided an income estimate for the period January 1972 to January 1973. Thus, while the expenditures reported in the diary can be related to the twelve-month calendar period 1973, the income estimates for those families theoretically reflect an approximate midpoint period of December 1972 to January 1973.

Another integration problem is accounting for the difference in the income level between the two survey components. We have already noted differences with regard to the completeness of reports as collected. In addition, because the quarterly interview questionnaire collected income in great detail, these data may generate higher family income estimates than those from the diary.

Finally, users should be aware that tapes of quarterly interview data will contain estimates of both family income before taxes and income after taxes, while the diary tapes will contain only the former. Estimates for personal income taxes were not collected in the diary.

One difference in the concept of expenditures on the tapes of the diary and interview surveys is in the treatment of gifts. Purchases of items given as gifts to persons outside the family are normally excluded from current consumption estimates. Expenditure data on the interview survey tape do not include such purchases, which are identified separately in a summary classification. However, they are not so separated on the diary tape. This difference is trivial since the incidence of gift purchases for the expenditure classes on the diary tape is known to be small.

An important issue in determining the form and detail level of data for the tapes is that of confidentiality. Appropriate controls on the level of characteristics and expenditure detail in the published tables ensure that no family or individual respondent can be identified.

No such controls can be put on the uses to which data from public use tapes will be applied. BLS, in complying with its own standards as well as those of the Bureau of the Census, has chosen to handle the problem by limiting the level of detail on the tapes. This has been done in three specific ways.

First, the expenditure data and the item detail of expenditures were carefully inspected for unusual entries. The item classification levels were defined such that a maximum of expenditure detail could be provided but above a level permitting identity of the respondent.

Second, family and family member incomes were carefully screened. Reports less than $2,000 and those exceeding $35,000 were presented as coded variables rather than as direct observations.

Third, the geographic information available at the microlevel was limited to include only a region code, a code identifying three size classes of standard metropolitan statistical areas, each further broken down by inside and outside central city, and one code for non-standard metropolitan statistical areas further defined by a urban-rural breakdown. No individual areas will be identified for the time being.

Tapes for both survey components contain a set of important characteristics about the family and family members. The tapes of diary data include references to week of collection, so that users may assess the frequency and dollar volume of purchases on individual items over time. The interview tapes will contain pointed characteristics on housing and housing services such as number of rooms and type of utilities used.

BLS has learned a great deal about the collection, processing, and dissemination of consumer expenditure and income data from the conduct of this survey. It would be unfortunate if another twelve years were to elapse before the survey could be conducted again, particularly in view of the need for current expenditure information. BLS has proposed to conduct a survey of this type on a recurring basis. The merits of such a program are obvious. Limited planning funds have been provided by the Congress, and the planning activities are already under way. Final, larger funding has not yet been approved. It is hoped that the administration and the Congress will provide this project with the priority it deserves.

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Discussion

Ronald A. Schrimper

The three papers in this session reflect a sense of new interest in the general area of demand and consumption analysis. Some of the same resurgence of interest with respect to demand and consumption analysis of agricultural commodities undoubtedly is related to increased interest in the type of forecasting and policy analysis described by Manchester. Recent demand-supply-price interactions in the agricultural sector may be partly responsible for renewed interest in these issues.

New types of empirical research using extensively detailed micro sets of data have been facilitated by improved computational capabilities in recent years. New capital stocks of data are always enticing to empirically oriented researchers. An important question is how new stocks of data can be used most efficiently to increase knowledge about demand and expenditure behavior. In view of existing computer capabilities, it is especially appropriate to review alternative proposals for additional exploitation of cross-section data. Many researchers are probably anticipating the availability of new national cross-section data sets for the United States provided by the 1972–73 Bureau of Labor Statistics (BLS) expenditure survey and the planned 1977 U.S. Department of Agriculture household food consumption survey.

If I correctly perceive the characteristics of the new BLS data from the highlights presented in Baer's paper and other sources, it presumably should be more detailed in the time domain but less comprehensive with respect to individual household expenditure profiles than previous studies. Data from the quarterly interview segment will be quite global with respect to expenditure categories (although not 100% coverage as noted by Baer) but will provide insufficient detail on food expenditures for many types of questions of interest to agricultural economists. On the other hand, more detailed information on food and a few additional subgroups of purchases will be provided by the diary component. Combining summary statistics from the two segments may provide accurate estimates of average expenditures for various subgroupings of households, but complete profiles of micro expenditure allocations for individual households will not be available. This shortcoming is extremely unfortunate. Nevertheless, governmental interests in data collection are not always compatible with ideal information systems for other types of basic and applied economic research. The resulting individual household BLS data sets will be useful for questions requiring aggregate expenditure categories or in cases where strong separability conditions are assumed to exist between food and nonfood expenditures. Some of the decisions about suppressing information already collected because of confidentiality and other guidelines will further restrict the data's usefulness to researchers. Justification of increasing funding for more frequent replication of activities of this type may require that more attention be directed to the information's potential for research purposes.

The methodological emphasis of the first paper is on the introduction of household characteristics into systems of relationships consistent with the interrelatedness of behavior resulting from household budget constraints. Attention is also directed to results of estimating separate models for subgroups of the population classified by selected household characteristics. Manchester advocates trying to understand behavior of different subgroups in the population as a way of improving knowledge about aggregate demand behavior.

Attempting to analyze cross-section consumer data within a consistent framework incorporating the interrelatedness of behavior imposed by household budget constraints is very appealing and increasing in popularity. The success of exploratory efforts in this

Ronald A. Schrimper is a professor of economics, North Carolina State University.

area is encouraging. Currently, this approach is not without its problems, because of certain restrictions and limitations as indicated by several caveats cited by Howe. Newer theories of household production and consumption also imply additional behavioral constraints over and above the budget constraint on market purchases. Some areas for additional work seem fairly evident before this approach is likely to address effectively the type of policy-oriented issues noted by Manchester. One of the most serious limitations of adapting linear expenditure systems for cross-section applications seems to be the implied linearity of Engel curves. Some suggestions regarding how this restriction might be relaxed are mentioned by Howe, but unfortunately this issue was not pursued in any of the empirical studies reviewed. The studies based on data from Mexico and Yugoslavia provided some indirect but conflicting empirical evidence on this point. Of course, income could be used as one of the criteria for subgrouping, assuming constant marginal budget shares within each group. An alternative way of handling this problem in a limited way is a spliced constant elasticity of substitution (CES) expenditure system proposed by McElroy. A description of the latter system, using McElroy's words is, "specifically, each Engel function consists of two abutting linear segments and thus marginal budget shares may differ between low and high levels of income" (p. 765). Other parameters in the spliced CES expenditure system are assumed to depend on sociodemographic characteristics of the household in much the same way as cross-section attributes have been introduced in adaptations of the linear expenditure system.

The manner in which sociodemographic characteristics of households are generally introduced into expenditure systems illustrates one of the theoretical shortcomings for understanding consumer behavior noted by Manchester. The problem exists since most cross-section empirical applications are within the context of household behavior, but theoretical structures are solidly rooted in terms of individual behavior. For example, the linear and spliced CES expenditure systems can be explicitly derived assuming an individual maximizes "reasonable" utility functions. The utility functions provide no information, however, concerning what characteristics of the household are expected to affect parameters of the model. For example, in practical terms, it is not obvious how age and sex composition differences among households should be represented. What are the guidelines concerning how many variables, what age groupings, etc., that should be used? Consequently, it is easily understood why many different characteristics are used for translating models in different ways or are used for subclassification of a sample. If theory is not capable of guiding empirical procedures, a wealth of new data can be overwhelming. Howe's admonition about the need for careful judgment to prevent criteria for subclassification proliferating so rapidly as to become unwieldy is especially important. Extensive subclassification can produce empty cells or some with too little data for estimation purposes.

Manchester's case for disaggregated models is based on interest in distributional effects of economic developments and policy changes in addition to his arguing that this will lead to improved estimation of aggregate effects. With regard to the latter point it is important to remember Grunfeld and Griliches's conclusion that disaggregated models may lead to inferior results because of specification errors associated with subcomponents. Consequently, if an ultimate goal is prediction of aggregate behavior, one may be better off with aggregate models. The following words of Grunfeld and Griliches seem especially cogent on these points: "It is undoubtedly true that disaggregation has certain advantages. In particular, it may suggest to us how to improve our theory. It may be futile, however, to expect that disaggregation will result in a better explanation of the aggregates without an appropriate change in the model. Different levels of aggregation require theories with different levels of abstraction" (p. 10).

There is no question in my mind about certain shortcomings in the current theory of demand, but I do not concur totally with some of Manchester's assessment. In particular, his comments about equilibrium and disequilibrium are troublesome. Casual empiricism suggests consumers are always adjusting to a variety of dynamic elements in our economy. Changes in consumer purchasing power, modified price relationships, introduction of new products, increasing educational levels, alterations in size and composition of households, and shifting occupa-

tional and geographical patterns of the population are among factors recognized as altering demand behavior. These can produce changes in consumption patterns, but is this change a symptom of disequilibrium or part of the dynamic process of adjusting to new equilibria? More information is needed about the adjustment process. Without this type of information, what basis is there for excluding households from analysis on the basis of disequilibrium and simultaneously concentrating on others assuming they are in equilibrium? Part of my concern is probably only a matter of semantics, but I am bothered by what criteria to employ for differentiating a household in disequilibrium from one in equilibrium.

Finally, I do not believe the concepts of optimization and maximization are ready to be discarded as useful elements in the theory of consumer behavior considering their fundamental role in all aspects of economic theory, especially in this bicentennial year of the *Wealth of Nations*.

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Editor's Note: Guy H. Orcutt, professor of economics, Yale University, was a discussant for this session, but he did not provide a written version of his comments.

Sources and Effects of Instability in U.S. Agriculture: Some Recent Experiences
(Jimmye S. Hillman, University of Arizona, Chairman)

Sources of Commodity Market Instability in U.S. Agriculture

Robert S. Firch

Cash receipts from U.S. farm marketings rose by 42% from 1972 to 1973, the largest year-to-year increase in sixty years. However, the 1916–17 and 1941–42 increases were only slightly smaller. Research completed in the early 1960s suggested that the importance of the farm income instability problem was at that time of small and declining importance (Firch 1964). The volatility of farm income that has occurred in the last ten years suggests a need to reevaluate the extent and sources of this instability.

Most of the literature on the sources of farm income instability has viewed the general business cycle and variations in farm output as the dominant sources of the instability (Schultz, Johnson, Cochrane, Hathaway, Firch 1964). During the last ten years the U.S. economy experienced a surge of inflation that was greater than in any comparable period since 1941–50. Recent research on the effects of general inflation during 1913–74 has revealed that the farm value, as measured by the U.S. Department of Agriculture market basket statistics, increased 1.77% for each 1% increase in the gross national product (GNP) implicit price deflator (Firch 1975), suggesting that inflation may have been an important source of farm income instability during the last ten years.

Analytical Procedures

The basic procedures used to develop the results that are presented in the following two sections are essentially those outlined in a previous article by Firch (1964). These procedures involve the application of regression analysis and the manipulation of regression coefficients with variances and covariances of the explanatory variables to allocate the variance of the explained variable to the variance of each of the explanatory variables and the covariance of each pair of the latter variables. In order to simplify the presentation and interpretation, each of the covariance terms has been allocated to the variance terms in proportion to the square roots of the variance terms.

All data series that are measured in dollar terms have been deflated by the GNP implicit price deflator on the belief that relative rather than absolute dollar changes represent the relevant variance to be studied. The computations of variances, covariances, and regression coefficients are performed on the first differences of the natural logs of the data series. The resulting first differences are good approximations of the percentage changes that would be computed by using the midpoint of the change as the base for the percentage calculation. First differences cause the variances and covariances to be based upon deviations from the trends in the data series. Hence, if a data series increases by the same percentage each year, it would have a zero variance. The economic interpretation is that market participants can readily adjust to increases of the same percentage each year, but a serious economic problem occurs when an important variable has highly variable year-to-year percentage changes and thus becomes unpredictable.

Robert S. Firch is a professor of agricultural economics at the University of Arizona.
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Analysis of Sources of Gross Farm Income Instability

The initial focus of the analysis is to discover the amount of variance of cash receipts of farm marketings, hereafter referred to as market receipts, that is correlated with the variances of the proposed explanatory variables of national income as a proxy for the general business cycle, the index of farm output, and the GNP implicit price deflator representing inflation.

Table 1 shows that the variance of market receipts in 1966–75 was much higher than it was in either of the two preceding ten-year periods, and the variance was nearly as high as during 1920–29. Farm output in 1966–75 had a greater variance than in the other two post-World War II periods but far below the variance of 1930–39. The variance of inflation appears to have trended downward from earlier to later periods. The low variance of inflation for 1966–75 may seem unrealistic, but the variance is based upon deviations from trend. The average year-to-year increase in the GNP implicit price deflator in 1966–75 was 6.2%.

Table 2 reports the variance of market receipts that correlated with the explanatory variables in selected time periods. Nearly 60% of the relatively high variance of market receipts in 1966–75 was correlated with the variance of the business cycle. Of the periods analyzed, only 1930–39 suggests a comparable dominance of the business cycle as a cause of variance in market receipts. Farm output shows only a relatively small contribution to the variance of market receipts in 1966–75 and seems to be the most important source of instability only in 1956–65 and 1920–29. Changes in inflation seem to have been an important source of market receipts instability for 1920–29, 1930–39, and 1946–55 but not in the two more recent periods.

Table 1. Variances of Market Receipts and Explanatory Variables for Various Time Periods

Time Periods	Market Receipts	Business Cycle	Farm Output	Inflation
		$(\%\Delta)^2$		
1966–75	134	11	22	4
1956–65	20	7	9	[a]
1946–55	28	20	16	16
1930–39	225	171	173	32
1920–29	138	34	35	39

[a] The value is less than 0.5.

Table 2. Variance of Market Receipts That Correlates with Explanatory Variables for Various Time Periods

Time Periods	Explanatory Variables: Business Cycle	Farm Output	Inflation
		$(\%\Delta)^2$	
1966–75	79	8	6
1956–65	1	12	2
1946–55	4	4	16
1930–39	127	14	35
1920–29	20	44	34

Since the 1974–75 recession was the most severe recession since the 1930s, it is perhaps not surprising that the business cycle should cause as much variance in market receipts in 1966–75 as the data of table 2 suggest. But the variance of market receipts attributed to the business cycle in 1966–75 as related to the size of the variance of the business cycle seems entirely out of proportion with this relationship for the four earlier time periods. Similar analyses completed in the early 1960s showed that the automatic stabilizers in the economy had become progressively more effective in stabilizing disposable income relative to national income over 1913–62 (Firch 1964). The automatic stabilizers include corporate income tax, corporate saving, personal income tax, net government transfer payments, the unemployment insurance program, and other welfare programs. Although the variance of year-to-year per capita dollar changes in national income was slightly more than half as large in 1966–75 as in 1930–39, the variance of disposable income in 1966–75 is less than one-fourth its value for 1930–39. It seems incomprehensible that the U.S. business cycle could have caused as much variance in market receipts in 1966–75 as the data of table 2 suggest.

A more satisfactory explanation of the 1966–75 farm income instability would likely result from adding a variable representing foreign demand for U.S. agricultural commodities. Foreign demand would logically be affected by the business cycles of major foreign purchasers of U.S. commodities, but the business cycles of other major economies seem to have become more closely correlated with the U.S. business cycle in recent years.

The U.S. business cycle variable in the current analysis probably tends to function as a proxy for foreign demand, and there is no feasible way to partition the two explanatory variables. The severe decline in the Peruvian fishing industry and the decision of the U.S.S.R. to purchase large quantities of grains in western markets to compensate for shortfalls in its own production also likely caused shifts in the foreign demand during the last ten years that had a high correlation with the U.S. business cycle. Another likely source of instability in recent years is the major instability in the exchange rate of the dollar against other major world currencies. The importance of this variable for U.S. agriculture was well documented by Schuh.

Attempting to identify the effects of exchange rate instability would likely yield more substantial results than attempting to isolate the total instability arising from foreign demand per se. Unfortunately, there exists no single variable that universally represents the exchange rate. The exchange rate of the dollar against the German mark was chosen to represent the exchange rate against all foreign currencies because Germany has a substantial trade with the United States, and it has one of the more stable economies.

Table 3 presents the results obtained from inserting the foreign exchange rate into the analysis for 1966–75. The exchange rate appears to be the most important source of variance in market receipts. A substantial part of the market receipt instability is still correlated with the business cycle, but as argued previously a substantial part of this probably has its source in foreign demand rather than the U.S. business cycle. The instability attributed to farm output rises slightly from the previous analysis, while the instability correlated with changes in inflation drops to an insignificant level. The earlier research indicated that farm prices were allowed to move freely during the 1971–73 period of price controls while the farm-retail spread and retail food price, as measured, were substantially constrained or delayed in their movement (Firch 1975). The price control program probably eliminated what otherwise might have been substantial correlation between market receipts and the GNP implicit price deflator during 1966–75.

Table 3. Variance of Market Receipts That Correlates with Explanatory Variables, 1966–75

Time Period	Explanatory Variables			
	Business Cycle	Farm Output	Inflation	Rate of Foreign Exchange
	(%Δ)²			
1966–75	48	9	[a]	69

[a] The value is less than 0.5.

The data of tables 1 and 3, when placed in perspective with Schuh's discussion of the exchange rate and U.S. agriculture, strongly suggest that government policies resulting in high commodity price supports and an overvalued dollar during 1946–55 and 1956–65 effectively buffered the variance of market receipts from the instability of foreign demand and largely explain the relatively low variance of market receipts in these periods. Historical perspective may eventually show that the high market receipts instability associated with the foreign exchange rate was unique to the 1966–75 period as the adjustment was made during 1971–73 from a system of fixed exchange rates and a substantially overvalued dollar to a system of primarily flexible exchange rates and a dollar essentially valued under free-market conditions.

Analysis of Sources of Income Instability for Cotton, Wheat, Corn, and Soybeans

Cotton, wheat, corn, and soybeans were selected for individual study because each represents a substantial portion of both cash receipts from farm marketings and exports of U.S. agricultural commodities. In recent years the four commodities have totaled about one-third of farm income and 60% of the export value of agricultural commodities. Direct government payments have been included as a part of the commodity income in these analyses because in some years during 1966–75 these payments became substantial portions of gross receipts for these commodities. To ignore the payments would in a sense overstate the variance of income. The same time periods were used, except that the data for corn and soybeans were unavailable in published sources for some of the earlier periods.

The analyses on the individual commodi-

ties were organized with a major objective of isolating the effects of inventory changes (as measured by changes in the quantity of carryover from the beginning to end of each marketing year) on the instability of income. This special interest in studying the effects of stock changes is based upon the belief that under certain circumstances such changes could substantially buffer the income instability from the other variables in the system.

The analytical procedure used was to include inventory changes as one of the variables in the least-squares regressions. The covariance terms and the variance term of the stock change variable were allocated to the other variables in a manner paralleling the analysis of the preceding section. The negative values in table 4 indicate that the nature of the covariance terms of that variable in that time period was such that it not only made no net contribution to the variance of income but also offset additional income instability from other variables.

Table 4 presents the variances of the individual commodity incomes for various time periods, and portions of this variance are attributed to the business cycle, changes in quantity produced, and exports. The export variable was represented by the rate of foreign exchange in 1966–75 and by quantity exported for other periods. The variances of commodity incomes are uniformly higher than the variance of market receipts for all commodities for the same time periods. However, the change in level of variance from one time period to another is proportionately less for the individual commodities than it is for total market receipts.

The table 4 data parallel the data in table 2 in suggesting that the general business cycle was the largest source of income instability during 1966–75. The business cycle is likely functioning as a proxy for certain shifters of foreign demand, even though the analysis includes a variable to represent foreign demand. The business cycle was apparently not an important source of commodity income instability for periods prior to 1966–75, except for wheat in 1930–39 and corn in 1946–55.

Cotton is the only commodity that shows quantity produced as an important source of income instability in 1966–75. In 1956–65 the largest portions of income variance were correlated with the production variable, and it is the most important source of income instability for cotton and wheat in 1946–55 and cotton and corn for 1930–39.

Table 4. Variance of Cotton, Wheat, Corn, and Soybean Income That Correlates with Explanatory Variables for Various Time Periods

Time Periods	Variance of Commodity Income	Explanatory Variables: Business Cycle	Quantity Produced	Exchange Rate or Exports[a]
	(%Δ)²			
	Cotton			
1966–75	432	241	61	101
1956–65	203	1	191	−1
1946–55	231	5	228	−2
1930–39	667	13	339	25
1920–29	749	−7	197	455
	Wheat			
1966–75	544	65	19	427
1956–65	230	4	194	2
1946–55	397	4	334	12
1930–39	789	266	101	96
1920–29	508	19	35	174
	Corn			
1966–75	349	322	−26	50
1956–65	110	11	25	29
1946–55	180	121	−3	33
1930–39	523	−3	75	22
	Soybeans			
1966–75	523	282	4	201
1956–65	121	1	74	38
1946–55	278	2	74	101

[a] The rate of foreign exchange was used for 1966–75, and the quantity exported was used for other periods.

Variations in export demand appear to have been important contributors to income variance for all four commodities in 1966–75. The export variable had the largest portion of income variance correlated with it for corn in 1956–65, for soybeans in 1946–55, and for wheat and cotton in 1920–29.

Table 5 reports the imputed stabilization by stock changes that otherwise would have been correlated with individual commodity income for each of the variables. This shows that, with the exception of wheat and soybeans in 1966–75 and cotton in 1956–65, inventory changes buffered variance that would otherwise have arisen from changes in production for each of the four commodities and for each of the time periods beginning after 1945. Stock changes were apparently very important stabilizers against production

Table 5. Stabilization of Cotton, Wheat, Corn, and Soybean Income by Stock Changes[a]

Time Periods	Business Cycle	Quantity Produced	Exchange Rate or Exports[b]	Total Stabilization (% of Income Variance)
	---------- (%Δ)² ----------			
	Cotton			
1966–75	−18	75	−7	11.76
1956–65	21	−28	1	−3.45
1946–55	−4	136	4	58.57
1930–39	8	244	3	38.25
1920–29	31	282	−157	20.79
	Wheat			
1966–75	38	−11	113	25.70
1956–65	4	16	[c]	8.47
1946–55	57	140	−11	46.97
1930–39	−94	−124	90	−16.25
1920–29	10	−2	−41	−6.52
	Corn			
1966–75	−174	207	−43	−3.03
1956–65	−7	12	−11	−5.64
1946–55	−32	38	−27	−11.53
1930–39	6	−76	72	0.31
	Soybeans			
1966–75	40	−4	17	10.02
1956–65	−2	18	8	19.02
1946–55	−1	41	−6	12.19

[a] Negative signs indicate destabilization.
[b] The rate of foreign exchange was used for 1966–75, and the quantity exported was used for other periods.
[c] The value is less than 0.5.

variations for cotton for 1930–39 and 1920–29. Stock changes seem to have amplified the income variance correlated with production variance for wheat and corn for 1930–39.

Stock changes appear to have been destabilizing in relation to the business cycle as a source of income instability for cotton and corn for 1966–75. Buffering of income instability against the business cycle seems to have been important for wheat and soybeans in 1966–75, for cotton in 1956–65 and 1920–29, and for wheat in 1946–55.

The inventory change variable was correlated with exports so as to reduce income variance for wheat and soybeans for 1966–75 and wheat and corn for 1930–39. For all other combinations of commodity and time period, stock changes amplified or had inconsequential effects for export quantity on income variance.

The data of table 5 indicate that inventory changes have generally been very effective in stabilizing income relative to changes in production. The only major exceptions to the tendency of stock changes to be more beneficially responsive to production changes than the other two variables were wheat and soybeans in 1966–75, cotton in 1956–65, and wheat and corn in 1930–39. This may be explained by the availability of better data on expected production than on the effects of the business cycle or export demand. In this way free-market participants can and do respond more effectively to the production variable than to the other variables.

The final column of table 5 shows the total stock change stabilization computed by summing the values of the three variables and dividing this by the variance of income that actually occurred. This shows that in 1966–75 stock changes were stabilizing for all but corn. Stock changes were destabilizing of income for cotton for 1956–65. The Commodity Credit Corporation accumulated huge quantities of cotton during 1956–65 and carried its largest accumulation into the beginning of 1966–75. The inability of stock changes to stabilize income seems strongly related to the freedom of free-market participants to influence stock changes, which is supported by the substantial stabilization for soybeans for each of the three periods studied. The Commodity Credit Corporation has had only very limited ownership of soybean stocks with its largest involvement coming in 1966–75. The corn income destabilization by the stock change variable may reflect its functioning within a very complex feed-livestock system rather than in the simple model specified in this analysis.

These studies strongly support the idea that the free-market stock change variable may truly be the forgotten variable in understanding the problem of farm income instability. Any commodity reserve program that is intended to stabilize farm income will likely neutralize a substantial amount of free-market stabilizing capacity before it achieves any net stabilization of income.

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Instability in the Capital Markets of U.S. Agriculture

C. B. Baker

Instability in capital markets of U.S. agriculture can be reflected in interest rates paid and charged by agricultural lenders, in loan volumes, total and by lender, and in loan quality of lender portfolios. In this paper I focus principally on interest rates and market shares. Both reveal important aspects of economic performance by participants in agriculture capital markets, as well as sources and forms of instability. My concern is limited largely to debt capital markets because they supply the vast bulk of market-supplied capital in U.S. agriculture.

Agricultural Capital Markets

Like all markets, capital markets evolve in response to opportunities for specialization and exchange among market participants. Exchange in capital markets is made possible through the use of negotiable debt instruments: money substitutes with time dimensions. Individuals, firms, and agencies differ in the values they place on debt instruments relative to money. These differences make financial markets possible and give rise to "financial intermediation," a process that transforms debt instruments in terms of liquidity, maturity, and/or security.

Informal Markets

As in the rest of the world, U.S. agriculture is financed through informal as well as formal capital markets, the informal ones consisting of individuals and trade lenders. Individuals include those who lend within the family, especially in helping the young start farming, and those who finance the sale of farm supplies or farm capital, including land as well as depreciable assets. Individuals account for more than 33% of loans secured by real estate (Melichar et al.). Sellers can use land purchase contracts to reduce tax liabilities on capital gains. In addition many retired farmers regard land purchase contracts as desirable investments. Terms of land purchase contracts are negotiated along with the price of land, limiting the significance of reported values of both. Thus, individuals remain strong competitors in the supply of debt capital to agriculture, as they function with a minimum of financial intermediation.

Individuals and others provide nearly 20% of non-real estate loans to farmers (USDA 1975). Trade credit is important in this category. Much of it is associated with machinery and equipment. Financing terms are often related to prices negotiated for the financed asset, making it difficult to interpret actual interest paid. Trade credit is also used to finance annual inputs: feed, fertilizer, fuel, etc. Annual inputs often are financed on open account for short periods as a matter of transaction convenience, perhaps with no interest paid (at least explicitly). In the case of both depreciable assets and annual inputs, credit is closely associated with merchandising practices of the trade firm, loans viewed in part as a method of expanding demand. Debt instruments in trade finance may and often do generate opportunities for financial intermediation and, therefore, financial markets.

Formal Markets

Formal agricultural capital markets consist of financial intermediaries who loan directly to farmers. Financial intermediaries can be sorted into the categories indicated in table 1.

C. B. Baker is a professor in the Department of Agricultural Economics, University of Illinois.

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Table 1. Farm-Related Financial Intermediaries Differentiated by Relation of Lender to Saver and Borrower

Relation to Saver	Relation to Borrowers in Agriculture	
	Specialized	Nonspecialized
Depository	None	Commercial banks
Nondepository	FCS units	Life insurance companies

The absence of a depository financial intermediary specialized in agricultural lending is interesting, especially in view of the success of savings and loan associations in urban mortgages and of savings units in agricultural sectors outside the United States.

Commercial banks provide a depository function for farmers as well as others. The banks then allocate funds made available by deposits among loan and investment alternatives, subject to organizational and legal constraints. Variability in the source of charter and in Federal Reserve membership varies the constraints under which banks allocate loanable funds. For example, in unit banking states a rural location can produce lending behavior that is heavily influenced by the dominance of farming and farm-related business activity.

The Farm Credit System (FCS) plays an especially interesting role in agricultural capital markets. In each of twelve districts the FCS units consist of a Federal Intermediate Credit Bank (FICB), a Federal Land Bank (FLB), and a Bank for Cooperative (BC). The FICB's buy debt instruments from local Production Credit Associations (PCA's), which make non-real estate loans directly to farmers. FICB's also discount a small volume of agricultural loans for commercial banks and other financial institutions. FLB's make farm-mortgage loans to farmers through local Federal Land Bank Associations (FLBA's). BC's loan directly to farm cooperatives. Debt instruments from farmers (and agricultural cooperatives) are sold by FCS units in national capital markets. The units are owned by the borrowers and are constrained by law to lend to agricultural participants and rural residents. Hence, they are specialized, functioning in a cooperative system with substantial control vested at the direct lending level.

The rate of interest paid by borrowers from FCS units is closely related to the interest rate paid to those who buy obligations of the units. Large city banks and life insurance companies are important buyers. The difference between interest paid and interest charged is for administrative costs of FCS units and for contingency reserves. Income also arises from investments made with proceeds from sale of capital stock to borrowers and with funds held in contingency reserves. The debt instruments are sold in national capital markets at interest rates only slightly higher than for obligations of the federal government that are comparable in maturity.

Life insurance companies comprise the remaining financial intermediaries who lend directly to farmers, largely in farm mortgage loans. Life insurance companies who participate do so cyclically and selectively. Being nonspecialized, they respond to profit perceptions as they allocate loanable funds among alternatives in loan and investments. The perceptions vary over the business cycle. Profits correlate positively with loan volume in relation to area. Hence, life insurance companies are active and competitive in areas of high land value and in periods when farm mortgage lending produces returns that compare favorably with alternative uses of company reserves.

Interest Rate Instability

Wholesale Capital Markets

Part A of table 2 provides for each lender the average interest rates paid for loanable funds, the annual average change for 1960–75 (column 1), 1960–67 (column 2), and 1968–75 (column 3), and the coefficient of variation from trend (CVT). Linear trend lines fitted to the data provide, with trend coefficients, estimates of the average annual changes. CVT's estimate variations from trend expressed in terms of means for the periods indicated. Differences in CVT's between the first and second halves of the period were tested for significance by comparing with the *F*-statistic the variance from trend, 1968–75, divided by the variance from trend, 1960–67. Computed ratios are shown in the fourth line for each lender. The probabilities of chance differences as large as those shown are less than 5%.

Table 2. Selected Statistics Relating to Interest Rates Paid and Received by Agricultural Lenders, 1960–75

Lender and Item	(A) Wholesale Markets (Interest Rates Paid)			(B) Retail Markets (Interest Rates Received)		
	1960–75	1960–67	1968–75	1960–75	1960–67	1968–75
FLB [a]						
Mean	5.49[b]	4.35[b]	6.62[b]	6.80[d]	5.74[d]	7.87[d]
Mean annual change[h]	0.26	0.13	0.24	0.22	0.01	0.13
CVT[i]	7	5	6	9	3	8
F: 1968–75/1960–67		4.0			9.0	
FICB-PCA[a]						
Mean	5.67[b]	4.20[b]	7.13[b]	7.41[e]	6.72[e]	8.11[e]
Mean annual change[h]	0.33	0.31	0.10	0.16	0.03	0.19
CVT[i]	19	13	19	9	6	10
F: 1968–75/1960–67		6.27			3.28	
BC[a]						
Mean	5.67[b]	4.23[b]	7.12[b]	6.25[f]	5.03[f]	7.47[f]
Mean annual change[h]	0.35	0.42	0.19	0.28	0.09	0.33
CVT[i]	19	11	20	13	5	14
F: 1968–75/1960–67		9.64			16.4	
CB						
Mean	4.46[c]	3.64[c]	5.28[c]	7.48[g]	6.84[g]	8.13[g]
Mean annual change[h]	0.21	0.36	0.10	0.15	0.004	0.21
CVT[i]	8	6	2	5	2	4
F: 1968–75/1960–67		5.0			6.5	

[a] Calculated from annual time series (USDA, forthcoming).
[b] Weighted net cost to Farm Credit System banks of bonds outstanding at end of year.
[c] Calculated from annual time series: maximum interest rates payable on time and savings deposits (time weighted averages, all accounts and deposits) (Board of Governors).
[d] From series on contract rates on loans through FLBA. In computing the average rates, each Farm Credit district is given equal weights; within districts, rates are weighted by number of days in force.
[e] From series on rates that represent interest (minus patronage refunds), service fees, cost of record searches, and filing and releasing mortgages, etc., paid by borrower as percentage of average loans outstanding during year.
[f] From series on midpoints of ranges reported. Excludes rates on loans secured by CCC documents.
[g] Calculated from annual time series (USDA 1974).
[h] Coefficient of trend variable in trend equations fitted to date for the period indicated in the column head.
[i] Square root of mean of squared deviations from trend values, as a percentage of mean values for respective time periods:

$$\left\{\left[\frac{1}{n-2}\sum_t (i_t - \hat{i}_t)^2\right]^{\frac{1}{2}} + \frac{1}{n}\sum_t i_t\right\}(100).$$

The three FCS units differ little in mean interest rates paid to investors in their obligations. FLB's borrowed for slightly less than the other two units in 1968–75 and for slightly more in 1960–67. For FLB's the mean annual change was less in 1960–67 than in 1968–75. For all three units, the CVT was more in 1968–75 than in 1960–67. Among FCS units, FLB's were lowest in CVT in all periods. There was little difference between FICB's and BC's in given periods.

The last three rows of table 2, part A, show comparable statistics for commercial banks. Large certificates of deposit are excluded. The average rates paid in 1960–75 are considerably lower for commercial banks than for FCS units. The average annual increase also was less. The CVT nearly matched that of FLB's. In 1960–75, the annual increases resembled those of FICB's. One mild surprise: the CVT was significantly smaller in 1968–75 than in 1960–67. For banks, market instability was substantially greater in 1960–67 than in 1968–75, whether measured by trend or variance from trend. Since no interest can be paid for demand deposits, the averages reported are doubtless overstated. No attempt was made to weight the rates (paid by volumes deposited with banks in exchange) for the various instruments.

Retail Capital Markets

Part B of table 2 shows comparable statistics for interest rates paid by agricultural borrowers. For all three FCS units the annual increase was more in 1968–75 than in 1960–67. For FLB's the greater increase in the second half was consistent with the increased average annual changes in rates paid. For the

other two FCS units, the trend in 1968–75 compared with 1960–67 ran counter to average changes in interest rates paid. The variable interest rate policy adopted by FCS units doubtless influenced the mean annual change in 1968–75. The CVT was significantly higher for all three FCS units in 1968–75 than in 1960–67.

Average rates commercial banks charged farm borrowers are shown to be higher than those charged by FCS units. The slope of the trend line reveals that on the average the annual change in rates charged farmers was extremely small in 1960–67, despite a sharply increasing cost of funds. In 1968–75 banks and PCA's charged about the same average rates. Finally, we note a small increase in 1968–75 in the CVT for rates charged by commercial banks, small because it was low throughout the period. The direction of change was to be expected, but it ran counter to the direction of change in CVT for rates paid by commercial banks.

Shane has argued that an important function for financial intermediaries is to moderate variations in interest rates. Table 2 suggests a somewhat mixed pattern in agricultural capital markets. The upward trends in interest rates were less at retail than at wholesale for all agricultural lenders when 1960–75 is considered as a whole. The CVT also is lower for all but FLB's.

The interesting comparisons are those between 1960–67 and 1968–75. All three FCS units absorbed much of the trend increase in the cost of loanable funds during 1960–67, as did commercial banks. During 1968–75, all but FLB's increased interest charged by more than rates paid. Moreover, for all but FLB's the CVT also was higher for rates received than for rates paid. Perhaps the second half performance of agricultural lenders represents a delayed reaction to events of the first half. On the other hand, it may more accurately foreshadow the future than does either 1960–67 or 1968–75 as a whole.

Instability in Institutional Sources of Capital

Figure 1 (USDA 1975) shows the net annual amounts loaned since 1960. In this period net annual farm real estate loans increased nearly 400% (Melichar et al.). Net non-real estate loans increased by nearly 300%. Real estate debt outstanding has exceeded non-real estate debt since 1965, the result of a high rate of increase in average farm size (especially land) during the 1960s, rapidly increasing land prices especially since 1970, and perhaps some refinancing of non-real estate debt.

Figure 2 (USDA 1975) shows the shares of farm real estate debt held by principal farm real estate lenders. FLB's increased their share gradually during the 1960s, rather more substantially after 1967, and sharply since 1971. The Farm Credit Act of 1971 increased the loan maximum for farm mortgages from 65% of normal agricultural value to 85% of market value of farm land.

A contributing factor has been a decline in loan funds from life insurance companies. Before 1967, they held a market share exceeding that of FLB's. They have since diverted funds from farm real estate lending because of accelerating lending costs, increased demand for personal loans provided for in policy contracts, and higher earning options outside farm real estate lending. State usury laws and other lending restrictions also may reduce their ability to compete in farm mortgage lending. In any event, the declining share held by life insurance companies is an outstanding feature of the farm real estate loan market.

Meanwhile, the share held by commercial banks held nearly constant at about one-eighth of the total, while the share held by individuals has fluctuated narrowly within a range of 36% to 40%. Commercial banks have held their share of farm real estate debt at rates somewhat higher than are charged by the other principal farm real estate lenders. From the borrowers' point of view, the higher interest rates may be partly offset by lower transaction costs. Yet higher interest rates may explain the continued demand for farm mortgage debt instruments by commercial banks.

"Individuals and others" retain the highest share of real estate debt. For reasons already noted, individuals are strong competitors in farm real estate lending, and, barring changes in tax laws, they are likely to remain so. Rates charged borrowers appear to have remained remarkably stable over 1960–73 (Melichar et al.). Interest rates are but one feature of negotiations in land sale and finance between seller and buyer.

Figure 3 reveals changes in the share of

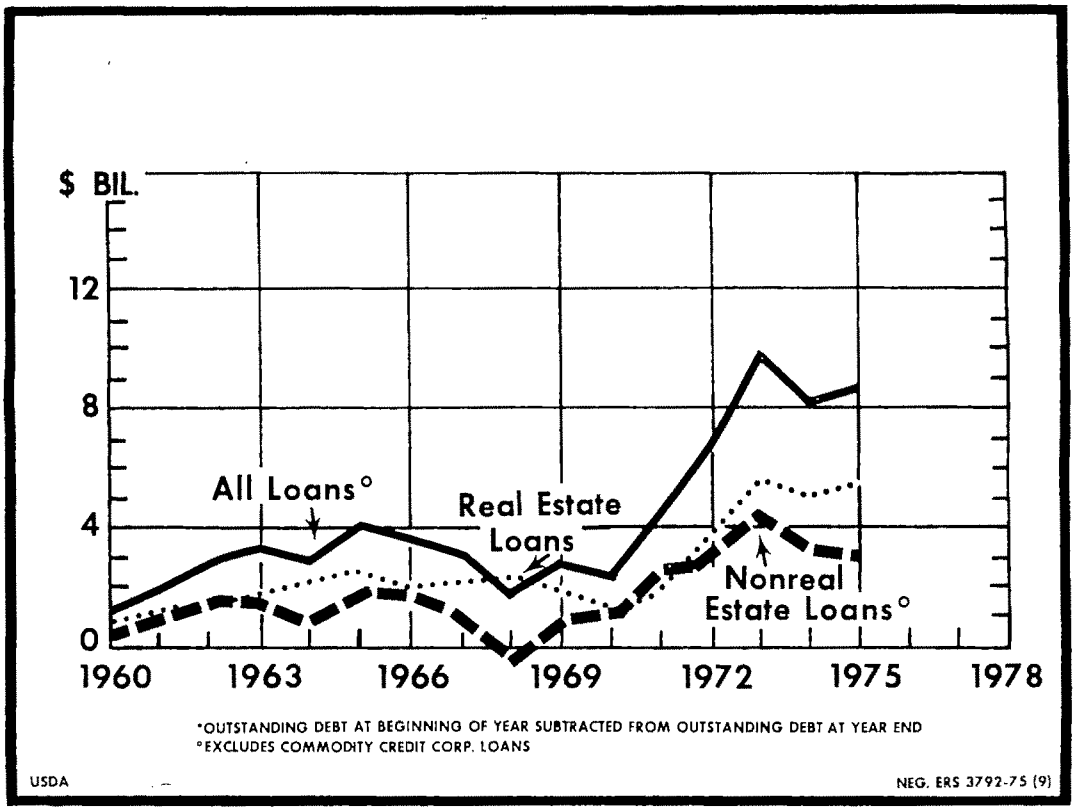


Figure 1. Annual net flow of farm loan funds

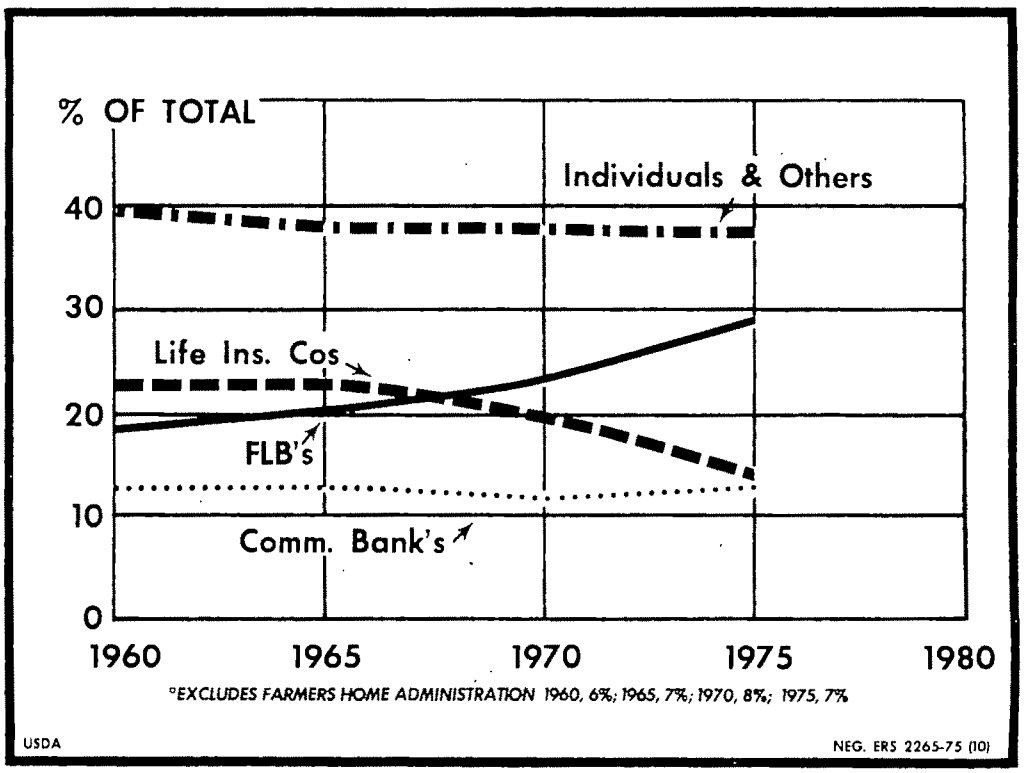


Figure 2. Farm real estate debt shares

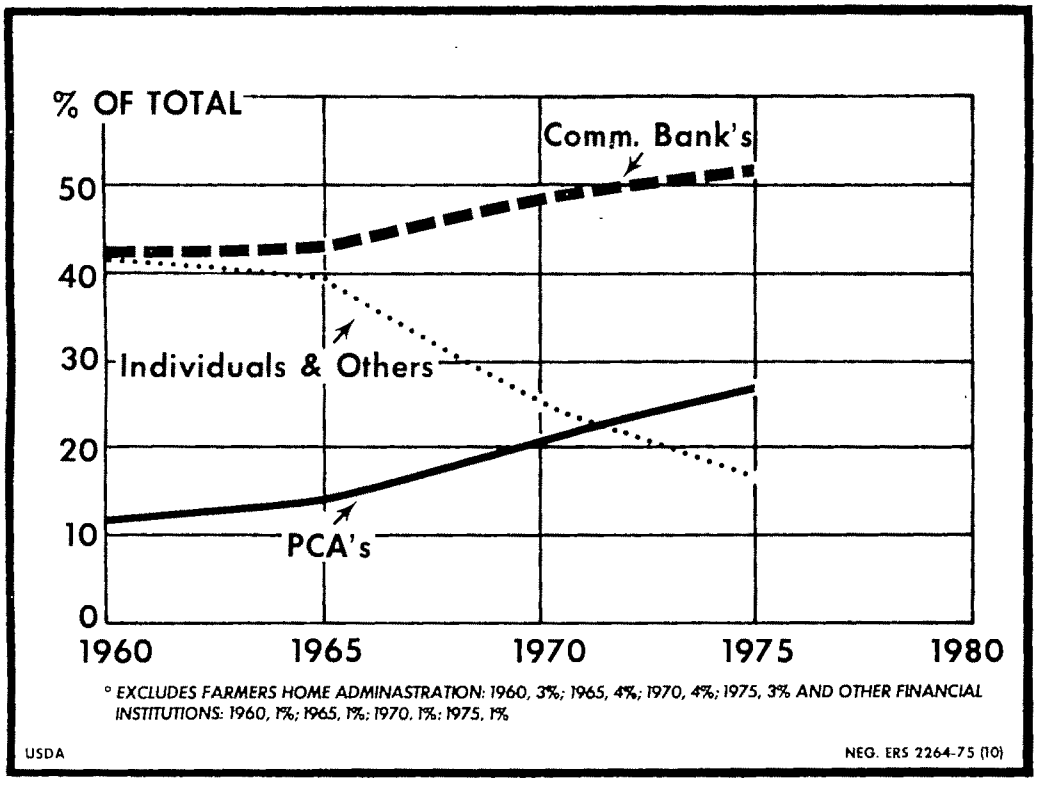


Figure 3. Nonreal estate debt shares

non-real estate farm debt among principal lenders. An important feature is the institutionalization of trade loans (reflected in "individuals and others") that has been occurring since 1965. Trade loans declined as a share of the loan market by thirteen percentage points between 1965 and 1970. Increases among PCA's and commercial banks in the years of sharpest decline in trade loans suggest that they may have shared about equally in the loans shifted from trade lenders. Otherwise, in contrast with life insurance companies versus FLB's, commercial banks have remained competitive with PCA's in the farm non-real estate capital market.

Finally, I note the share of farm non-real estate loans held by the Commodity Credit Corporation (CCC). CCC loans are nonrecourse loans to finance crop inventories. They reached nearly 13% of non-real estate debt in 1962. However, as a part of price support programs they constituted receipts from marketings in the 1960s. In any event, treasury-financed CCC loans have now dropped off sharply, being offset in part by commercial loans to farmers and other participants in the grain trade.

Banking Structure and Market Shares

Many rural banks are small, independent, and isolated from national financial markets. Hence, they are unknown to market participants and unable to generate financial transaction units of a size required in such markets (Sloan). Participants in national financial markets report that $200 million or more outstanding in a given type of paper is needed to support a good secondary market (Doll) and needed, in turn, to provide the liquidity required for marketing debt instruments. Outstanding debt farmers owe to commercial banks suggests that volume need not be an insurmountable problem, given that an adequate intermediary can be interposed between the rural banks and national capital markets.

Where the interposed intermediary is a branching headquarters of a bank, the question arises that a flow of funds may be activated from rural to urban users instead of the reverse (Melichar, Snider). Given the "entrapment" of funds in small local bank deposits (Baughman), a first consideration

suggests considerable economic merit in that effect. However, some dislocations also could be expected. Local equilibria now depend on rural deposits bearing relatively low rates of interest. Rates charged farmers did not (and do not) reflect these low rates. Indeed, in the early 1960s rates farmers paid commercial banks exceeded the urban prime rate and differed little from rates charged by PCA's.

Should a reorganized flow of funds add competitive pressures for local deposits in rural areas, farmers would face potentially higher rates of interest. In these circumstances, PCA interest rates might become effective "ceilings" on rates charged farmers by commercial banks. A study in Wisconsin suggests that branching need not convert the flow to net urban, though the results there may have been determined by the terms of branching permitted (Rosenblum).

There remains the question of economic effects of a net urban or net rural flow of funds. If net urban, then small banks in rural areas are transformed (partially) from retailers to wholesalers of loanable funds. Most buyers of FCS unit obligations are large city financial intermediaries, including money market commercial banks. Some of the balances now used for direct loans to farmers might instead flow to banks that buy FCS unit obligations. How much of the flow would be channeled to FCS units is a moot question. Sloan has suggested a marketing process designed to restrain a net urban flow of funds and possibly induce a net rural flow of funds.

Summary and Conclusions

The evidence suggests relatively little instability in agricultural capital markets in aggregate. The volume of funds borrowed by farmers has increased over the past several decades in both nominal and real terms. The increase in nominal terms exceeded inflation rates, as reflected in the value of assets in the farm sector especially before 1972. The increase in real terms reflects high expected payoff from use of borrowed funds in agriculture and lack of alternative means of financing added resources in agriculture. The farm sector remains essentially proprietorship (i.e., "full liability") organized.

Interest rates have varied at "wholesale" much like interest rates paid by financial intermediaries who raise funds for lending to other sectors. Interest rates have varied at "retail" perhaps a bit less than for other sectors. A contributing factor is the importance of small rural commercial banks in unit banking states (or states with limited branching). The imperfect markets tend, on balance, to restrain the flow of funds from rural to urban users. FCS units also have been able to absorb part of the variability of interest rates at wholesale, insulating farm borrowers from some of the extremes of the recent past, though the pattern is a bit mixed in recent years.

The past may not be a reliable basis for estimating the future behavior of agricultural capital markets. Further branching among commercial banks seems likely, on balance, to reduce the isolation of rural locations, producing interest rates that reflect more sensitively those paid elsewhere. Rapid growth of FCS units and the tendency in the past to absorb national variations in interest rates has exacted a price in terms of liquidity of FCS units. FCS units probably will be less able in the future than they were in the past to absorb variations in wholesale rates of interest.

Thus, future agricultural borrowers are likely to face capital markets that look increasingly like the capital markets of other borrowers. If the general increase in variability since the 1970 period is not dampened, then still another element of risk is increased for farmers. The changes also seem likely to reduce the supply or increase the cost of debt capital for a given equity base, adding to the demand for or supply price of equity capital in agriculture.

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Asset Values and Liabilities of U.S. Farmers in Unstable Commodity and Capital Markets

David A. Lins

Previous papers by Firch and Baker identified sources of and changes in instability in commodity and capital markets. Changes in instability are likely to create modifications in the desired portfolio of farm operators, landlords, and other farm investors. The purpose of this paper is to review the instability of farm assets and liabilities held by U.S. farm proprietors.[1] The paper is divided into four main sections: first, the structure of assets and liabilities in the farm sector; second, farm asset and liability instability in comparison with the instability in commodity and capital markets; third, concepts of investment in a risky environment in relation to observed changes in the balance sheet for the farm sector; and fourth, existing econometric studies relating to farm assets and liabilities and the potential for including risk considerations in such studies.

Structure of Farm Assets and Liabilities

Farm real estate (land and buildings) is the major asset of farm proprietors (table 1). The value of land and buildings increased in nominal value from $130.6 billion as of 1 January 1960 to $422.3 billion as of 1 January 1976. However, only very modest increases in the real value of real estate have occurred. Real estate assets have accounted for an increasing percentage of total assets of farm proprietors on a nominal basis but for a relatively constant percentage on a real basis (table 2).

The nominal and real value of all non-real estate assets have also increased since 1960. In percentage terms, the largest increase in both nominal and real terms has been in farm machinery and motor vehicles. Also, the real value of crops stored on and off farms has held up well despite the withdrawal of most government support programs. Non-real estate assets as a percentage of total assets have trended downward on a nominal basis but have trended upward on a real basis. This pattern, coupled with the slight decline in the relative importance of the real value of real estate, suggests a trend toward more intensive farming practices.

Total financial assets of farm proprietors have increased in nominal value since 1960. However, farm proprietor investments in U.S. savings bonds have declined on a nominal basis. On a real basis, the holdings of demand deposits and currency has also declined since 1960. Investments in cooperatives have increased in both nominal and real terms. As a percentage of total assets, financial assets have declined since 1960.

Liabilities of farmers have increased tremendously since 1960. Total debt increased from $24.8 billion as of 1 January 1960 to $90.7 billion as of 1 January 1976. Real estate debt as a percentage of total liabilities has increased substantially, reflecting in part the increasing importance of real estate in the asset composition of U.S. agriculture. Trends in holdings of financial assets coupled with trends in debt outstanding suggest that farm financial assets are declining in importance as a source of liquidity for farm proprietors. This in and of itself does not imply a decline in the overall liquidity of farm proprietors.

David A. Lins is an agricultural economist with the National Economic Analysis Division, Economic Research Service, U. S. Department of Agriculture, and is an assistant professor in the Department of Agricultural Economics, University of Illinois.

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[1] Farm assets and liabilities held by U.S. farm proprietors refer to those assets and liabilities recorded in the *Balance Sheet of the Farming Sector* (USDA). These figures are intended to record only farm assets, debts, and equities of farm operators and landlords; nonfarm assets are not included.

Table 1. Balance Sheet of the Farming Sector, 1 January 1960–76

	Nominal Values				Real Values			
	1960	1970	1975	1976	1960	1970	1975	1976
	Billion $							
Physical assets								
Real estate	130.6	206.9	371.1	422.3	177.9	183.0	183.7	183.8
Non-real estate								
Livestock and poultry	15.3	23.5	24.6	29.5	17.7	19.6	22.2	21.4
Machinery and motor vehicles	22.7	32.3	55.8	69.0	26.3	28.6	30.9	31.1
Crops stored on and off farms	7.7	10.9	23.2	20.7	9.7	12.7	9.6	11.4
Household equipment and furnishings	9.6	9.7	15.4	17.0	9.3	8.9	10.1	9.9
Financial assets[a]								
Deposits and currency	9.2	11.9	15.0	15.3	10.4	10.8	8.6	8.2
U.S. savings bonds	4.7	3.7	4.3	4.4	5.3	3.4	2.5	2.3
Investments in cooperatives	4.2	7.2	10.5	11.6	4.8	6.6	6.0	6.2
Total	204.0	306.1	519.9	589.8	261.4	273.6	273.6	274.3
Liabilities[a]								
Real estate debt	12.0	29.2	46.3	50.9	13.8	26.8	27.4	27.5
Non-real estate debt								
Excluding CCC loans	11.6	21.1	35.2	38.4	13.3	19.4	20.8	20.8
CCC loans	1.2	2.7	0.3	0.4	1.4	2.5	0.2	0.2
Total liabilities	24.8	53.0	81.8	90.7	28.5	48.7	48.4	48.5
Proprietors' equities	179.2	253.1	438.1	499.1	232.9	224.9	225.2	225.8
Total	204.0	306.1	519.9	589.8	261.4	273.6	273.6	274.3

Source: USDA.
[a] Real values are obtained by dividing nominal values by the index of prices paid by farmers.

Instability of Farm Assets and Liabilities

There are a number of ways to measure instability. Two measures used here are the coefficient of variation (CV) and the coefficient of variation from trend (CVT).[2] These two measures of instability for balance sheet components are presented in table 3. Because of aggregation, these measures may not be an accurate indicator of instability experienced by individual farm operators. Calculations are done in both nominal and real terms for 1960–76. Since variations in nominal values of physical assets contain both quantity and price effects, CV's and CVT's for the own-price deflators for physical assets are also reported.

As shown in table 3, the CV as well as the CVT are substantially different from one balance sheet component to the next. For nominal balance sheet values, the three categories of financial assets display the three lowest CVT's, suggesting that on a nominal basis financial assets are the most stable asset in the balance sheet for the farm sector. Liabilities exhibit the next lowest CVT's, but the CV's are high relative to financial assets. Nominal values of physical assets appear to be the most unstable component of the balance sheet. In particular, the nominal value of crops stored on and off farms has a higher CVT than any other asset or liability.

Fluctuations in nominal values of assets can arise due to price or quantity changes. Fluctuations in physical units can be determined by reference to balance sheet values in real terms, while fluctuations in price can be measured by reference to the assets own-price deflator.

CVT's and CV's for balance sheet items in real terms are also presented in table 3. Results suggest that the physical stock of land and buildings used in U.S. agriculture is more stable than the physical stock of any other asset used in farming. Results also suggest that the real values of financial assets are no more stable than physical assets.

Are balance sheet values for farm proprietors more stable than commodity prices and financial markets?[3] Comparisons of annual

[2] Instability might also be measured as deviations between actual and expected outcomes. This measure requires knowledge of expectations of farm operators.

[3] Annual coefficients of variation and annual coefficients of variation from trend for prices received and paid are 30.3 and 22.8 for index of prices received on crops, 26.5 and 13.5 for index of prices received on livestock, and 26.3 and 12.7 for index of prices paid by farmers.

Table 2. Balance Sheet Components as a Percentage of Total Assets and Liabilities, 1960–76

	Nominal Values				Real Values			
	1960	1970	1975	1976	1960	1970	1975	1976
	(%)							
Physical assets								
Real estate	64.0	67.6	71.4	71.6	68.0	66.9	67.2	67.0
Non-real estate								
Livestock and poultry	7.5	7.7	4.7	5.0	6.8	7.2	8.1	7.8
Machinery and motor vehicles	11.1	10.5	10.7	11.7	10.1	10.5	11.3	11.3
Crops stored on and off farms	3.8	3.6	4.5	3.5	3.7	4.6	3.5	4.2
Household equipment and furnishings	4.7	3.2	3.0	2.9	3.5	3.2	3.7	3.6
Financial assets								
Deposits and currency	4.5	3.9	2.9	2.6	4.0	3.9	3.1	3.0
U.S. savings bonds	2.3	1.2	0.8	0.7	2.0	1.2	0.9	0.8
Investments in cooperatives	2.1	2.3	2.0	2.0	1.8	2.4	2.2	2.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Liabilities								
Real estate debt	48.4	55.1	56.6	57.2	48.4	55.1	56.6	57.2
Non-real estate debt								
Excluding CCC loans	46.8	39.8	43.0	42.3	46.8	39.8	43.0	42.3
CCC loans	4.8	5.1	0.4	0.5	4.8	5.1	0.4	0.5
Total liabilities	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source; USDA.

CV's and CVT's for prices received and paid by farmers reveal that the stability of these items is about comparable to that for physical assets. Financial assets and liabilities appear to be more stable than prices received and paid by farmers. Interest rates on borrowed funds appear to be more stable than any of the physical assets or liabilities of farm proprietors (see CVT's reported by Baker). Financial assets appear to be slightly more stable than interest rates paid for borrowed funds.

Table 3. Measures of Instability in the Value of Balance Sheet Items for the U.S. Farm Sector, 1960–75

	Nominal Balance Sheet Values		Real Balance Sheet Values	
Balance Sheet Item	Annual Coefficient of Variation[a]	Annual Coefficient of Variation from Trend[b]	Annual Coefficient of Variation[a]	Annual Coefficient of Variation from Trend[b]
Physical assets[c]				
Land and buildings	39.9 (39.1)	17.3 (17.3)	1.1	0.3
Livestock and poultry	34.2 (27.6)	20.2 (18.3)	7.2	2.1
Machinery and motor vehicles	38.7 (31.2)	19.4 (16.3)	6.9	2.3
Crops stored on and off farms	40.8 (42.7)	23.7 (30.5)	9.9	9.1
Household equipment and furnishings	24.3 (18.5)	15.2 (11.9)	6.4	4.9
Financial assets				
Deposits and currency	20.4	5.0	7.6	7.3
U.S. savings bonds	8.1	7.4	25.6	2.2
Investment in cooperatives	30.8	8.1	8.9	6.4
Liabilities				
Real estate debt	44.8	10.7	22.7	7.2
Non-real estate debt including CCC loans	37.6	11.2	12.9	7.6

[a] The coefficient of variation is the standard deviation divided by the mean times 100.
[b] Each balance sheet item was regressed against time for 1960–75.
[c] Items in brackets are coefficients of variation and coefficients of variation from trend for the own-price deflators for physical assets. The deflator used for financial assets and liabilities (the index of prices paid by farmers) has an annual coefficient of variation of 26.3 and a coefficient of variation from trend of 12.7.

Investment in a Risky Environment

Determination of farm proprietors' responses to changes in their economic environment requires an understanding of their decision processes. Considerable progress toward such an understanding has been gained through the use of a decision theory concept of profit maximization. However, profit maximization as the sole criterion has come under increasing scrutiny and question. In particular, decisions involving risky choices may be poorly explained by a decision criterion based solely on maximization of profit.

In relation to investments in balance sheet components in a risky environment, a particularly useful conceptualization of the decision process appears to be expected utility theory and the closely associated theory of portfolio balancing. According to the latter theory, the decision to invest in an asset is not made independently of decisions regarding other assets and liabilities. This suggests a decision-making framework in which investment and financing decisions are considered simultaneously. (Ample evidence exists to suggest that in U.S. agriculture investment decisions are influenced by their impact on financial alternatives and vice versa.) The desired portfolio balance is that which maximizes expected utility.

Knowledge of risk aversion characteristics of investors provides useful insights to their decision processes. Working independently, Pratt and Arrow formulated two measures of risk aversion: absolute risk aversion and relative risk aversion. Decreasing (increasing) absolute risk aversion exists if the amount of wealth invested in risky assets increases (decreases) with wealth. Decreasing (increasing) relative risk aversion exists if the percentage of wealth invested in risky assets increases (decreases) with wealth. Application of absolute and relative risk aversion concepts require one to define "risky" and "secure" assets. Arrow defined secure assets as money. Cohn et al. argue that the classification is an empirical issue.

There seems to be little doubt about the existence of decreasing absolute risk aversion. However, considerable disagreement exists for relative risk aversion. Arrow hypothesized the existence of increasing relative risk aversion on theoretical grounds, while Tsiang argues for its existence based upon empirical observation. Alternatively, Friend and Cohn et al. provide empirical evidence of decreasing relative risk aversion.

Do farm proprietors display decreasing absolute and increasing relative risk aversion? Table 1 provided a balance sheet for the farm sector for selected years. Clearly, wealth of the farm sector has increased substantially over time. If farm proprietors display decreasing absolute risk aversion, one would expect the investment in "risky assets" to increase. This has occurred since all assets, except U.S. savings bonds, have increased in value over time. Likewise, if farm proprietors display increasing relative risk aversion, then the proportion of risky assets should decrease as wealth increases.

If one defines risky assets as all nonmoney assets, then the proportion of risky assets of farm proprietors has increased rather than decreased, consistent with decreasing relative risk aversion.[4] Mere observation of an increasing proportion of risky assets in the portfolio of farm proprietors is not sufficient evidence of decreasing relative risk aversion. Such changes could reflect modifications in transactions demand for money, changes due to changing age and tenancy patterns, etc. However, the observed increase in the proportion of risky assets warrants empirical investigation to determine if farm proprietors display decreasing relative risk aversion. This is especially so given the frequency of the assumption in agricultural studies of a quadratic utility function—a utility function that reflects increasing relative risk aversion.

Risk does not result from instability per se. Rather, it is generated by a discrepancy between actual and expected outcomes. If unstable outcomes do not diverge from expectations, instability should generate no risk responses. Thus, understanding the process by which expectations are formed is a crucial first step in evaluating the magnitude of risk and investment in a risky environment. It seems plausible that the divergence between actual and expected outcomes increases as the degree of instability increases.

Risk Considerations in Studies on Farm Assets and Liabilities

It is useful for discussion purposes to classify empirical studies into four subjective catego-

[4] Defining money as a risk free asset is open to question because the purchasing power of money may be quite unstable.

ries: micronormative, micropositive, macronormative, and macropositive. Distinctions among these categories are not exact, but most studies can be fairly well identified as belonging in one category. Discussion here will focus on the nature of empirical studies in each category that relate to farm assets and liabilities.

Micronormative studies concerning assets and liabilities of individual farm proprietors have been important research topics for some time. Firm growth studies using linear programming (LP) were in vogue during the late 1960s and early 1970s. Studies of this nature relied upon an income or net worth maximization criterion but generally did not include risk considerations in the decision criterion. Some did include liquidity responses as a means of dealing with risk. More recently, greater emphasis has been placed upon quadratic programming (QP) techniques to include considerations of risky investment alternatives. In addition, alternatives to QP that account for risk have been proposed. These include focus-loss constraint programming (Boussard and Petit), chance constrained programming (Charnes and Cooper), and adaptive LP (Chen and Baker). While not all of these techniques have been used to study farm proprietor demand for assets and liabilities, the potential for such study exists.

Considerable effort has been devoted to micropositive models of farm proprietors demand for assets and/or liabilities. Studies range from estimation of demand for a single asset or liability to simulation studies that estimate the entire balance sheet for farm proprietors. Again, risk considerations have been largely ignored. Some micropositive studies (Just 1974) have included risk responses, but these studies have not focused directly on the demand for assets and liabilities.

Recently, Just (1975) proposed an adaptive risk model of the form $y_t = f(x_t^*, z_t^*, u_t, v_t, w_t)$, where y_t is a decision variable, x_t^* is the expected value of variable 1 (price), z_t^* is the expected value of variable 2 (yield), u_t is the subjective variance of variable 1, v_t is the subjective variance of variable 2, and w_t is the subjective covariance between variable 1 and 2. Just suggests that this model reflects "diversifying as well as risk-aversive response to a changing risk structure" (1975, p. 9). While this formulation represents an important first step, particularly for supply response studies, it is useful to recall the effects of changes in wealth on risk aversion. If farm proprietors display either increasing or decreasing relative risk aversion (as opposed to constant relative risk aversion), the proportion of risky assets in the portfolio will change as wealth changes. Consequently, unless relative risk aversion is constant, the level of wealth will influence investment in risky assets. Inclusion of the wealth term to the Just formulation creates no problems, as long as wealth is not highly correlated with other independent variables.[5]

Macronormative models of the agricultural sector have generally focused on production responses to changes in policy variables and, more recently, on resources and the environment. Despite the normative nature of these models, the results are often used to suggest or predict the behavioral responses of farm proprietors. To my knowledge, the literature is void of macronormative models focused toward understanding the portfolio composition of farm proprietors. Macronormative studies have not included considerations of risk. Hazell and Scandizo have provided the theoretical justification for inclusion of risk in such models. But due to lack of knowledge on how to sum utility functions, empirical studies of this nature are not likely for some time.

A large number of macropositive models have focused on farm proprietor investment in a single asset such as land, machinery, or buildings. A smaller number of studies have looked at the entire complement of balance items. Lins and Melichar have provided empirical estimates of balance sheet components, but these studies have not included a simultaneous determination of assets and liabilities as suggested by portfolio balancing theory. More recently, Penson has developed a simulation model that does include a simultaneous determination of the demand for physical and financial assets and liabilities. However, to my knowledge, none of the macropositive studies have included risk considerations in the theoretical framework, although liquidity considerations were subsumed in Penson's work.

While this review of studies of the demand

[5] The wealth term here is initial wealth that will vary across individuals if the study is cross sectional and across time if the study is time series. Expected terminal wealth is likely to be highly correlated with expected prices.

for farm assets and liabilities is brief, one clear fact emerges. Macro models, particularly macropositive models, have not included risk considerations in their theoretical constructs. At least two explanations seem plausible. First, instability in commodity and financial markets has become more pronounced only in recent years. There is likely to be some recognition lag and some lag in incorporation or risk responses into modeling efforts. Efforts to include risk consideration in macropositive models have now been started. Second, Just shows that inclusion of the risk term introduces noise that "prevents accurate estimation of risk term coefficients and biases associated statistics toward insignificance" (1975, p. 13). This bias results from the aggregation process and is likely to be more serious as diversity of the observational units increases. Great diversity exists, particularly for crop and livestock assets of U.S. farm proprietors. Diversity that would lead to aggregation bias would seem to be less severe for financial assets and liabilities; that is, costs of borrowed funds and returns on financial assets appear to be less variable than returns to livestock and crop production.

Concluding Comments

Evaluation of the effects of risk on farm proprietors' demands for assets and liabilities is in the infancy stage. Some micro-oriented studies have made strong advances in developing and testing conceptual frameworks for incorporating risk responses. However, few of these studies have specifically looked at the entire spectrum of investments in physical assets of farm proprietors. No studies, to my knowledge, have considered the effects of risk on the demand for financial assets and liabilities. This result is not surprising because of the degree of stability in capital markets. Yet capital market instability is becoming of greater concern, as evidenced by the recent initiation of futures markets for both long- and short-term interest rates and by the move to variable interest rate loans. Consequently, the effects of financial market instability on the demand for both financial assets and liabilities appear to warrant empirical investigation.

Many applications of risk response behavior of farm proprietors have proceeded without adequate consideration of the process by which expectations are formed. Likewise, there is little empirical evidence of increasing, constant, or decreasing relative risk aversion. Empirical evidence on these points seems crucial to a better understanding of farm proprietors' responses to risk.

As a final thought, researchers should be cognizant of the underlying forces that generate instability in farm commodity and farm capital markets and result in instability in the demand for farm assets and liabilities. If these underlying forces (weather, world food demand, government programs, etc.) generate a new era of stable farm commodity and farm capital markets, what will be the value of research studies geared toward answering questions of instability? Clearly, this is a risk faced by researchers concerned with risk response issues.

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Discussion

Bruce L. Gardner

The term instability covers too broad a subject area. Not everything that fluctuates repays study. The papers narrow the topic down in two ways: by limiting the variables whose instability is studied and by limiting the type of change that counts as instability. I have some disagreements in both areas.

What Changes Count as Instability?

Lins makes the pertinent point that instability is important because it creates risk; yet not all fluctuations create risk. It is possible for changing events to be predictable. Unfortunately, it is difficult to separate predictable and unpredictable fluctuations empirically.

All three authors apparently agree that trend changes in a variable should not count as instability. Thus, inflation is equally stable if it occurs at any constant rate in Firch's approach, whether that rate is 10% per year, 5%, or 0. Baker uses the coefficient of variation around trend for his interest rate calculations, which is almost the same as Firch's approach. For Baker, an arithmetic trend counts as stability, while for Firch an exponential trend counts as stability. Lins does not make as definite a commitment, providing measures both of the coefficient of variation around trend and of the coefficient of variation around the mean.

None of the authors provide a convincing rationale for excluding trend, and only trend, from instability measures. In many cases it is reasonable to treat a trend, either arithmetic or exponential, as not contributing meaningfully to instability because the trend can be readily adapted to by economic agents so that change does not imply risk. But some cases do not fit this idea. The interest rate trends in Baker's data do not seem to have been adapted to, since expectation of a continuation of these trends would imply long-term interest rates far higher relative to short-term rates than in the term structure that currently exists. In this case, the coefficient of variation around the mean would probably be a better indicator of instability than the coefficient of variation around trend.

Moreover, if it is reasonable to omit trend, why is it less reasonable to say that slow changes in trend or regular cyclical patterns can also be adapted to, so that variations should be computed around a typical cyclical pattern? Indeed, one can sometimes make a good case for excluding a variation that has no regular pattern but is predictable in advance.

Instability of What?

The reason for interest in instability in agriculture is that it has important consequences for the well-being of consumers and producers of agricultural products. The instability most closely related to well-being is that of the incomes of farm people and of food prices in the budgets of consumers.

Baker's paper does not attempt to say what variation in interest rates has to do with instability in prices, incomes, or other variables. It is not clear, in fact, to what extent he regards interest rate instability as a source of instability in other variables or as an effect of instability. While Lins' paper deals with some of the most interesting effects of instability in agriculture, he does not really come to grips with the question of how commodity market instability in recent years has been connected with farm asset instability or asset values. In Firch's paper, it is not clear why he chooses market receipts as the variable whose instability is to be explained or what implications he thinks instability in receipts has for instability of income.

While the severe space limitation undoubtedly explains some of this problem, nonetheless, I think all three papers are deficient in tying their particular investigations to the ultimate concern with the effects of instability on people's well-being.

Bruce L. Gardner is a senior staff economist at the Council of Economic Advisers.

Particular Criticisms of the Papers

I will concentrate on Firch's treatment of sources of instability, in part because his paper has more substantive analytical content than the others and in part because it leaves so many loose ends.

The approach Firch takes in his first part is to fit regressions of the form $\Delta \ln PQ = b_0 + b_1 \Delta \ln Y + b_2 \Delta \ln Q + b_3 \Delta \ln \bar{P}$, where Q is farm output, P is its relative price, Y is real national income, and $\bar{P}$ is a general price index. Then he uses the regression coefficients as he outlines to calculate the entries in his table 2. I have several comments on Firch's use of this method.

It is natural to distinguish between agricultural and nonagricultural sources of instability in the farm sector, and Firch's approach accomplishes this neatly. In the 1966–75 results, Q, the only agricultural source of instability, has a strikingly small effect on PQ despite its being the most unstable of the independent variables. One reason for this could be that the aggregate elasticity of demand for U.S. farm output is not far from -1, so that PQ does not change much with Q.[1] It would be interesting to see equations that explain farm price instability instead of receipts, where Q should be more important.

The farm output variable has the drawback of being endogenous due to supply response, so that one is not confident of having an estimate of the effects of exogenous output-shifting events such as drought or blight. Although the supply elasticity is undoubtedly small, it may still be troublesome. For example, it is likely that the increased farm output associated with the very large increase in farm receipts between 1972 and 1973 (which dominates the 1966–75 data) was in part a response to increasing demand and not a source of instability at all in the way the decline between 1973 and 1974 in farm output (due to reduce crop yields) was.

There is also a problem with lags between output changes and changes in receipts. For example, the corn blight reduced output in 1970 compared to 1969, but a good part of the resulting high corn prices was received by farmers in 1971. This may be why the Q variable in the 1966–75 corn equation works poorly.

Market receipts are deflated to measure the price of farm products relative to all other goods. While this is appropriate for analyzing the effects of farm output, it would be better to use nominal receipts for regressions including the inflation rate. Inflation creates instability primarily by changing nominal values of commodities, so naturally a relatively small effect of inflation is expected in regressions on the real value of receipts.

The overwhelming importance of real national income in 1966–75 is surprising. The main action in this variable is the large rise in 1971–73 and the decline in 1973–75, which indeed parallels the movement of farm receipts closely. However, before going to great lengths to interpret these results, it should be noted that the opportunity for statistical error is even greater than is usually the case in regression analysis. For each ten-year period there are nine observations on the dependent variable and five degrees of freedom in the regression. Though Firch does not present regression coefficients or their standard errors, the degree of precision required for accurate point estimates would seem very difficult to attain in the regressions he fits.

In the analysis of foreign sources of instability, some regressions use the quantity of exports and some the dollar-mark exchange rate. Both create problems. With respect to exports, when poor foreign crops boost export demand, instability is expected due to higher U.S. farm prices and receipts. But when U.S. crops are large, lower prices and hence increased exports are expected, which are stabilizing just as additions to carry-over stocks are stabilizing. Firch's approach lumps together both stabilizing (endogenous) and destabilizing (exogenous) export changes.

The exchange rate variable is also dubious because the mark-dollar rate, important as West Germany is, still provides the appropriate exchange rate for less than 10% of U.S. agricultural exports (6.7% in 1974–75), and the mark is not a typical foreign currency.[2] A trade-weighted dollar would have been a better choice for the exchange rate variable.

[1] The b_2 coefficient should allow an estimate of the elasticity of demand for agricultural output since $\Delta \ln PQ/\Delta \ln Q = 1 + \eta$, where η is the elasticity of demand. Moreover, the sign of b_2 indicates whether $\eta \lesseqgtr -1$. It is not obvious that $|\eta|$ is far less than unity because of the substantial share of U.S. farm output that is exported.

[2] In particular, during the crucial year 1973 the dollar depreciated much further against the mark than against the yen, Canadian dollar, and other important currencies (Salant).

Also, while macroeconomic trade variables are important, the 1966–75 regressions go too far in excluding real food-sector determinants of export demand (such as foreign production).

While the treatment of stock changes in the individual commodity analysis is imaginative, the theoretical basis for the method used is not clear, nor are the methods of measurement. One problem is that to the extent changes in stocks offset destabilizing changes in other variables, the dependent variable will not vary. With perfect stabilization, the regression coefficients would be zero. The basic idea of looking at the covariance terms between stock changes and changes in output, national income, and foreign demand is an interesting one and worth carrying further. Again, because of the few degrees of freedom, one should not read too much into the particular regression results. The conclusion that CCC stocks have been less stabilizing than free-market stocks is an important hypothesis. But it would be premature to accept it on the basis of the table 7 regressions.

One particular point of apparent inconsistency exists in Lins' paper. In discussing whether his data show risk aversion, Lins takes nonmoney assets as relatively risky. But earlier he finds that the real value of financial assets is no more stable than the real value of physical assets. This is not surprising, since with unstable rates of inflation money may be more risky to hold than land. It would be interesting in Lins' table 3 to see bracketed terms for financial assets such as those presented for physical assets that would measure the coefficient of variation of the price level.

Finally, the authors should be complimented for their objectivity. Issues of instability arouse deeply felt opinions in almost everyone, so that discussion can easily degenerate into an exchange of unsupported assertions and value judgments. This sin these authors have not committed. Still, it is worth keeping in mind the passionate interest aroused by the bottom line issues of who gains and who loses from instability and exactly in what sense instability may be said to be undesirable and what should be done about it. These issues and their policy implications make the research efforts reported in this session practically important and worth pursuing further.

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Discussion

B. Delworth Gardner

The authors of these three papers have provided important empirical information to be utilized extensively by the profession and others interested in the instability problem in agriculture. Only one of the three papers, however, attempts to identify and quantify the causal factors associated with instability, and this discussion will deal mostly with that paper. I hope that Firch will interpret this attention to his work as a compliment rather than a criticism. He has provided analytical results to interpret and methodology to evaluate. The instability issues associated with the other two papers will be understood to the same degree only if Lins, Baker, or other scholars take the Firch approach and postulate some causation and test some hypotheses.

I am, however, less than satisfied with the three papers taken as a composite for quite another reason. Moreover, I find the same missing element in nearly all discussions of the instability problem. The missing element is a rationale for looking at instability and why the economist, in particular, has special interest in it. The issues need to be put into some kind of welfare framework that will permit us to gauge the importance of the efficiency and equity impacts of instability and to evaluate the gains and losses that will be incurred by public policy designed to reduce instability.

It has been an article of faith in the profession that fluctuations in prices, income, and wealth create risk and uncertainty that, in turn, produce inefficiency in resource use. This may well be true, but empirical support is quite feeble. Lins correctly points out that even instability per se does not generate risk. Risk is generated by the discrepancy between actual and expected outcomes. But even if instability does produce risk and uncertainty and producers are highly risk averse, it is crucial that the resulting misallocation be quantified if one is to know the social costs of instability.

In the world of reality, the economic issues are very complex. For example, in discussions of the instability problem, it is seldom pointed out that stabilization policies in principle can also create resource misallocations. If real shifts in demand and/or supply occur, then resulting fluctuations in prices are indeed necessary signals to consumers and producers that consumption and production should be altered. To prevent these fluctuations in prices by stabilization devices is to distort the signals and produce misallocation. Empirical studies are needed as well that establish the extent of this misallocation.

Of course, not all fluctuations in prices may result from actual shifts in demand and/or supply. "Noise" is the term that describes the discrepancy between perceived and actual shifts in supply and demand and the transitory and random influences on market prices. Allegedly, eliminating this noise may produce a better allocation of resources. I am uneasy about this simplistic rationale for stabilization policy, however. The trouble is that it is not known by simply observing price changes whether or not these changes are due to actual shifts in demand and/or supply or whether they result from noise. It is not even clear that there is any foolproof way of differentiating between the two. If they cannot be distinguished, then how it is known whether more good than damage is being done by stabilizing?

Moving on to a discussion of the Firch paper, it will be useful to belabor the obvious and present a simple conceptualization of Firch's analytical model. His dependent variable is annual farm marketings, the product of prices and marketed output summed over all relevant agricultural commodities. Fluctuations in marketings can result from two sources—fluctuations in prices and fluctuations in market output. So long as the demand and supply curves are not perfectly

B. Delworth Gardner is the director of the Giannini Foundation, University of California, Berkeley, and a professor of agricultural economics, University of California, Davis.

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elastic or perfectly inelastic, changes in prices and quantities occur simultaneously. A shift in supply produces a shift in the market price and a shift in the quantity demanded. The critical parameter in this case is the elasticity of demand. A shift in demand causes a shift in the price and a shift in the quantity supplied, and the critical parameter is the elasticity of supply. The greater the elasticity of these curves, the less the price volatility caused by a given shift in the other curve.

Firch's business cycle variable is primarily a demand shifter. It affects marketings through large changes in price and small changes in the quantity supplied, assuming a steep supply curve or vice versa if the supply curve is flat. His foreign trade variable is also a demand shifter and, if significant in explaining fluctuations in marketings, does so in similar fashion conceptually to the business cycle variable. Changes in the farm output variable simply move the equilibrium point along the demand curve, and price changes and quantity changes are in opposite directions. Elasticity of demand determines relative price and quantity changes and whether marketings increase or decrease. Finally, the analytical effects of the inflation variable are much more complicated a priori, as inflation can shift both demand and supply curves depending on what its impact is on relative prices of complements and substitutes in consumption, on relative input prices, and on a host of other factors. Space limitations do not permit a full development.

The point in this brief excursion into price theory is to suggest that Firch's regressions would have been easier to understand and interpret had the variables been specified in these terms. Otherwise, some questions surface. For example, a valid regression analysis postulates "independence" among the explained and the explanatory variables in the sense that they do not measure the same thing or are mutually affected by other variables. In Firch's regression, farm marketings and the business cycle seem to satisfy the independence assumption fairly well, as do farm marketings and foreign trade and, perhaps, farm marketings and inflation, although the identification problem may exist in the case of this variable. But what about the farm output variable? Since market receipts are composed of the product of price and quantity and quantity is farm output, these two variables are related by definition. The question is whether or not there is significant specification bias in the regression results.

There are also other questions about this variable that might be raised. As output shifts, if prices are free to move, a new equilibrium price will be established. Firch's data suggest that the quantity variable is becoming less important over time as an explanatory factor. There are several reasons why this might be so, a priori, and it would be very revealing to know which are empirically significant. Perhaps relative changes in output are not so great as they once were and thus explain less, or perhaps prices have been freer to move in recent years to offset increases in output in determining value of marketings than in earlier decades, dampening the effect of output changes. Finally, as suggested above, the impact of a given output change on marketings depends on the elasticity of demand. Perhaps the demand curve facing American producers of farm commodities has become much more elastic as foreign demand has become more significant in recent years and many more substitutes are available for American-produced commodities. If so, price fluctuations would have been reduced because of a given supply shift. Firch may counter that the significance lies in that the variable is less important than it once was for whatever reason. Granted, but, in judging whether or not it will remain so, it would be helpful to know why.

I have a similar problem with the business cycle variable and the interpretation of the regression results. The message of Firch's 1964 paper was that the business cycle is becoming less powerful over time in producing instability of farm marketings. The alleged reason was the recent implementation of built-in stabilizers that stabilize demand. His data in this paper, however, suggest that the business cycle was quite significant in the last decade. How can this be, since the stabilizers are presumably even more potent now than they were a decade ago? The answer given by Firch is that his results are probably a statistical mirage. Firch believes that this variable is not so significant as his data suggest; he offers the explanation that, because of interdependencies among national economies, the business cycle variable for the United States may be good proxy for foreign demand as well. In other words, there is allegedly high multicollinearity between

these independent variables producing distortion in the coefficients, which might well be true. A simple correlation coefficient between the two could provide evidence.

It is the logic that is not clear. If the two variables are correlated because of interconnectedness in national economies, then foreign demand should have shifted leftward with U.S. demand during the world recession in the last decade. But this is not consistent with the facts. The U.S. recession coincided with huge increases in shipments abroad. Firch then recalls the Russian purchases and the Peruvian fishing problem. Clearly these factors contributed to sales abroad, but they were random influences causally unconnected with business cycle impacts. In fact, these influences, a priori, should have offset some of the decreased demand due to purely business cycle effects. Thus, I am not sure how they could have increased the explanatory power of the business cycle variable.

Firch goes on to postulate a role for a shifting foreign exchange rate in explaining annual changes in farm marketings. I am tempted to agree that the large one-time shift in relative prices of American-produced commodities in world markets resulting from the dollar devaluation produced a large shift in the demand curve. One would have expected a large average annual quantity increase after the devaluation compared to before, but only one first difference would be affected by the devaluation unless a complicated set of lags occurred in supply and/or demand. After the initial shock of the devaluation, it would have been the foreign exchange float that produced the instability of annual farm marketings. This should be called the "Firch effect," as contrasted to the "Schuh effect" that Firch postulates as the important demand shifter.

There is another foreign trade effect that has probably been overlooked in Firch's paper. In 1975, Johnson argued that instability of American farm prices (and indirectly farm marketings) was the result not of shifts in foreign demand or even decline in U.S. foreign exchange rate but instead resulted from the fixed-price policies of U.S. trading partners. Johnson points out that when internal prices are stabilized in some countries by controlling the flow of trade, all of the adjustments in the variability of world supply and demand must be made elsewhere. Stabilized internal prices do not serve the function of influencing either domestic consumption or production. Price elasticity of demand for imports and price elasticity of supply for exports, whichever is relevant, is effectively zero. He goes on to show that the needed adjustments for the 1970s fell upon two groups of countries—the major grain exporters and the low-income countries that imported grain. Johnson may have identified the international source of much of the farm marketings instability. If Johnson is right and if U.S. trading partners do not change their fixed-price policies, the U.S. may be faced with instability resulting from these trade forces for a long time.

I come now to a final question about the Firch data. In his tables 4 and 5, an exchange rate variable was used for 1966–75 to represent the foreign demand shift, but "quantity exported" was chosen as the variable for other periods. Since the variable's contribution to instability is higher for 1966–75 than for the other periods for all commodities (with one exception in each table), one might wonder if this is due to specification differences in the variable rather than real differences among periods. Clearly, the variables are quite different; the exchange rate is a relative price while quantity exported is not.

The paper by Lins contains interesting information on the composition of farm sector balance sheets over time, but I do not quite know what the data mean or how significant the instability problem is. The sector data do seem to imply "absolute risk aversion" and "decreasing relative risk aversion." What this means in terms of efficient resource allocation in decisions is not analyzed. In fact, as pointed out above, Lins suggests that the empirical study results of the effects of risk and uncertainty are indeed meager. Lins has provided a start in providing some of the basic data. It is hoped that he and other researchers will follow up with the more analytical work. I am not necessarily opting for highly sophisticated econometric studies of the Just variety that Lins cites. Less elegant tests of hypotheses of the Firch type are also needed.

The Baker paper is very similar to the Lins paper. Baker's data provide several sets of phenomena that could be explained. One is the variation in the rates of interest charged by various lenders over time. Another is the

relatively greater instability in the wholesale capital markets than in the retail markets. Why do these wholesalers absorb some of the fluctuations arising from credit demand and supply shifts compared to retailers? A third question is the changing proportions of real estate and non-real estate loans made by various lenders.

Baker argues that there is relatively little instability in agricultural capital markets over time, presumably compared to other capital markets in the economy. What is the explanation for this? It might be due to the relatively large proportion of capital funds available to agriculture from stable and subsidized governmental sources, which may have the effect of limiting the fluctuations of competitive private funds.

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Notes

The Index of Medical Underservice as a Predictor of Ability to Obtain Physicians' Services

John E. Kushman

This paper presents an evaluation of the Index of Medical Underservice (IMU) as a predictor of a population's ability to obtain physicians' services. Evidence from California's Medi-Cal program shows that the IMU fails to reflect the experience of persons who are nonwhite or rural. An adjustment to the IMU is suggested that may produce a more adequate measure.

The IMU was developed by the Health Services Research Group at the University of Wisconsin. The Department of Health, Education, and Welfare used the IMU to designate areas as underserved for the health maintenance organization program. Priority was given to applications for grants, loans, and contracts where at least 30% of the persons served by a health maintenance organization would come from underserved areas or populations. The index was computed for all U.S. counties, and all counties scoring below the median were designated as underserved. For counties not so designated the computations were repeated for census tracts (metropolitan counties) or census county divisions (nonmetropolitan counties). The same cutoff point was used to choose tracts and divisions for designation as underserved (Health Services Research Group 1975a).

The use of an index to identify underserved populations is increasing. The federal government is attempting to make an index part of an identification scheme to be shared by a number of agencies (U.S. Dep. Health, Education, and Welfare 1975, pp. 47–52). The identified areas are to be targets for coordinated programs. Within the Department of Health, Education, and Welfare (HEW), the Health Underserved Rural Area initiative and the Rural Health Initiative are efforts to coordinate and concentrate the resources of the National Health Service Corps, Maternal and Child Health Services, Neighborhood Health Centers, and other programs in rural areas. Each program has its own eligibility criteria, but funds for coordination of services are available only if the area is underserved according to the IMU.

In recognition of the decreasing availability of primary personal health services, the California legislature passed the Song-Brown Family Physicians Training Act in 1973. The act provides for state support to programs training family physicians, primary care physicians' assistants, and nurse practitioners. The training has to be conducive to practice in "medically underserved rural, multi-cultural, or lower socioeconomic communities" (California Health Manpower Policy Commission, p. 13). The proportion of graduates who actually practice in underserved areas is specifically included as one criterion for evaluating program performance. A provisional list of underserved areas has been compiled by combining the critical manpower shortage areas of the National Health Service Corps, areas designated under the HEW Loan Forgiveness/Loan Repayment Program, and underserved areas of the health maintenance organization program.

Evidently, any bias in the IMU will distort the allocation of resources. If the index fails to capture disadvantages associated with being rural or nonwhite, the resources of a substantial and growing number of programs will be misdirected toward urban dwellers and whites.

Development and Limitations of the IMU

The Health Maintenance Organization Act required the secretary of HEW to designate underserved areas within one year. The time constraint made it impractical to base the designations on objective data regarding health outcomes of health maintenance organizations or health service utilization. In order to meet the requirements of the legislation, it was decided to use a multiattribute utility model to predict how experts would assess the adequacy of health services in an area.

The value, even the necessity, of the IMU arises from the fact that there is no generally accepted definition of medical underservice, and yet experts tend to agree in their evaluation of areas. Consensus expert opinion can be used to designate underserved areas without a determination of whose criteria are

John E. Kushman is an assistant professor of agricultural economics at the University of California, Davis.

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"correct."[1] Furthermore, consensus evaluation appears to be possible on six interrelated constructs: scarcity of health services, ability to obtain personal health services, quantity of health resources per capita in the area, impact of an additional physician on the health status of the population, and ability to obtain physicians' services. One index may serve to predict expert assessments on any of the six constructs (Health Services Research Group 1975c).

Once consensus in evaluating sites had been established, the IMU was constructed. Seventy-two variables thought to be associated with the adequacy of health services in an area were identified. The variables were viewed as direct indicators of adequacy and as proxies for other constructs. The variable list was narrowed to four on the basis of ready availability of reliable data for appropriate population units and on the ability of a combination of the variables to predict expert assessments. The variables eventually used in the IMU were percentage of the population in poverty, percentage 65 years old and older, infant mortality rate, and number of primary care physicians per 1,000 persons.

The four variables were combined into an index using rules explicated by a panel of experts.[2] In order to validate the predictive power of the index, rankings obtained with the index were compared with the actual assessments of local health experts and a national panel of experts. The national panel knew only the four variable values for the sites. The local experts were personally familiar with the sites and were permitted to use any data they wished in forming evaluations. Assessments were compared for sixty-two counties, towns, cities, and groups of census tracts in Michigan, Arizona, and Wisconsin. Fifty-seven experts provided 1,662 assessments of adequacy. Comparison of assessments from the model and the expert panels established that the model predicted expert judgment with acceptable precision (Health Services Research Group 1975a, pp. 15–16). Pearson product-moment correlation coefficients for the predicted and actual assessments were 0.80 or greater with one exception. Spearman rank order correlation coefficients were 0.78 or better, again with one exception (Health Services Research Group 1975b, p. 177).

The IMU's careful development as a consensus evaluation gives it wide acceptability. It predicts quickly and inexpensively the assessments experts would make if they actually visited sites. Predictive validity on a number of dimensions increases the useful scope of the index. There are, however, a number of qualifications regarding the validity of the index.

The first qualification is that the correlation coefficients used as evidence for predictive validity may be artificially inflated by the nonrandom choice of sites or experts. A second qualification is some evidence that the consensus is less strong in evaluating census tracts in metropolitan areas. There is no apparent difficulty with towns, counties, or whole cities. A third qualification is the impossibility of evaluating the results of any intervention with the index. The IMU predicts expert assessments under present institutional arrangements and levels of service. Intervention that alters the arrangements or levels of service would not be reflected in the index (Health Services Research Group 1975b, pp. 177–80).

A more fundamental limitation of the IMU is that it has not been validated as a predictor of actual health status, change in health status, resources in the area, or barriers to care. The index only predicts subjective expert judgments. For many of the six constructs predicted, no objective measure is available or widely accepted. Where objective evidence is available and accepted, the validity of the index must be tested. It is ultimately the objective phenomena that are of interest, not expert opinion.

Evaluation of the IMU and an Alternative

Despite the wide acceptance and usefulness of the IMU, there is concern that it does not adequately capture variations in ability to obtain physicians' services between rural and urban areas and among populations of different racial and cultural compositions. Rural residents may be disadvantaged by distance barriers as well as the restricted practices and out-of-date techniques of older rural physicians. Members of some racial and cultural groups probably receive less adequate service due to provider discrimination and residential segregation, which isolates them from care.[3] Holahan and Davis and Reynolds have presented evidence that nonwhites in Medicaid and Medicare receive fewer physicians' services than whites in the same programs.[4] Davis has shown that among low-income persons nonwhites and rural persons receive fewer services than other persons.

The power of the IMU to predict ability to obtain physicians' services can be evaluated only when the population of interest is specific. The target population for many current and anticipated government

[1] The consensus appears to be limited to persons who share a set of "prototype assumptions." (*a*) Additional personal health services contribute positively to health status. (*b*) A population of low socioeconomic status will benefit more from additional health services than a population of higher status. (*c*) The ability to obtain health services is positively related to socioeconomic status (Health Services Research Group 1975c).

[2] For details of the procedure, see Health Services Research Group 1975a, b, or Nuckton and Kushman. A regression model was also used to obtain an aggregation scheme, but the regression coefficients were unstable across samples (Health Services Research Group 1975b, pp. 176–79). The judge-explicated model was used in program designations.

[3] These concerns have been expressed in instructions to Comprehensive Health Planning Agencies on requesting additions to the health maintenance organization list of underserved areas. They have also been of concern to the California Health Manpower Policy Commission (see also Burnett).

[4] Davis and Reynolds found no significant effect in the Medicare program outside the South.

programs is the very poor and includes persons with handicaps that otherwise qualify them for special assistance. Persons eligible for Medicaid are approximately representative of the target population. Most eligibles have low incomes and qualify for at least one categorical aid program, e.g., Aid to the Blind, Aid to the Permanently and Totally Disabled, or Aid to Families with Dependent Children. In California's Medi-Cal program, about 91% of the eligibles met the requirements for a categorical program aside from the income and property requirements in early 1976. About 84% met the income and property requirements as well (California Dep. Health).

Nationwide, approximately 61% of the poor were covered by Medicaid in 1974 (Davis, p. 129). It is not known how many of California's poor are covered, but the population of eligibles appears to be similar in size and composition to the population of poor and near poor. Medi-Cal eligibles in 1975 were about 12% of the population, while persons with incomes below 125% of the poverty level were around 15% in 1969 (U.S. Dep. Commerce). Ignoring 16% of the eligibles for whom no data are available, it was estimated that in the recent past 70% of the Medi-Cal eligibles have been white and 87% have resided in metropolitan areas.[5] The 1970 census shows persons below 125% of the poverty level income to be 80% white and 89% metropolitan.

Medi-Cal claims per eligible for physicians' services in January and February 1976 were taken as a measure of ability to obtain physicians' services.[6] Claims are an imperfect measure of services to the extent that the number of services per claim varies with specialty and mode of practice (e.g., solo versus group), but they are the best available measure and should reveal systematic effects of significant magnitude. Claims are a preferrable measure to expenditures in the absence of information on prices. Medi-Cal covers almost all physicians' services that are deemed medically necessary by the individual physician without limitations.[7] The most important exclusions appear to be cosmetic surgery and allergy treatments when the problem is not debilitating and psychiatric visits in excess of two per month.

The first empirical question is whether claims per eligible are accurately predicted by the IMU.[8] Using as units of observation the fifty-eight counties of California, the regression estimate is

$$(1)\qquad \frac{Claims}{Eligibles} = \underset{}{-0.1222} + \underset{(4.07)}{0.0052}\,IMU, \qquad R^2 = 0.2286;$$
$$\qquad\qquad\qquad\qquad\quad (1.13)$$

t-values are in parentheses. The equation establishes that the IMU predicts an objective measure of ability to obtain physicians' services. A higher value indicates more adequate services, and claims per eligible are positively related to the IMU. The association is weak, as the regression explains only one-fifth of the variation in claims across counties.

In order to test the hypothesis that the IMU adequately reflects barriers faced by rural and nonwhite persons, regressions including the percentage of the population that are nonwhite and urban as independent variables were used. If the IMU is an inadequate predictor, the new variables should significantly increase the explanatory power of the equation. We would expect the percentage nonwhite and the percentage urban to be related negatively and positively to claims, respectively. The new equation (t-values in parentheses) is

$$(2)\quad \frac{Claims}{Eligibles} = \underset{}{0.0557} + \underset{(1.67)}{0.0023}\,IMU - \underset{(1.50)}{0.0029}\,Nonwhite + \underset{(4.15)}{0.0016}\,Urba$$
$$\qquad\qquad\qquad\qquad

rved. Program resources may then be diverted to eas that are underserved but do not represent able practice opportunities. Ultimately, the failure o identify many underserved areas may lead to negative program evaluations. It may seem extremely difficult to redress the disadvantages of nonwhites and rural persons that prompted the programs largely because the operating procedures direct resources away from those groups.

Faced with evidence that the IMU has limited usefulness in comparing areas of different rurality and racial composition, the policy maker has a number of options, each of which involves some sort of ad hoc procedure. The most obvious course is to use the IMU to choose only among areas that are similar in rurality and racial composition. There are difficulties, however, in deciding what cutoff value to use in each type of area, in forming a classification, and in allocating resources among the classifications.

Another alternative is to use only the objective nformation of claims per eligible. Table 1 juxtaposes he IMU and claims-per-eligible rankings for California counties. The rank order correlation between the rankings is only 0.45. Policy decisions usually take the form of declaring counties in the lower half or lower quartile to be underserved. Sixty-two percent of the counties below the median IMU are also below the median of claims per eligible. For the lower quartile the figure is 57%.

It may be objected that the subjective information of the IMU should not be entirely ignored. The IMU is based on an interdisciplinary consensus and may add information about persons not eligible for Medi-Cal. These objections are more compelling for programs requiring wide public support to be successful and having a relatively broad target population. A way around the difficulties is to combine the specific and objective evidence from claims per eligible with the more general and subjective information of the IMU to form a new index. Assume, for instance, that the effects of rurality and race are proportionally the same for all elements of the target population as for Medi-Cal eligibles, while other effects are adequately predicted by the IMU. A hybrid index can be calculated by the following steps: (*a*) choose a "standard county" arbitrarily; (*b*) for each other county find the fraction of claims per eligible predicted by equation (2) that is due to the difference between rurality and racial composition in that county and the standard county; (*c*) if claims would be higher with the characteristics of the standard county, deflate the county IMU value by the fraction found in step (b); if claims would be lower, inflate; and (*d*) compare the new hybrid index values that have been inflated (deflated) in accordance with the proportional advantage (disadvantage) of each county relative to the standard county.

A hybrid index for California counties according o the rules above was computed. The ranking is iven in column three of table 1. The rank correlaon between the IMU and the new index is high at

Table 1. Ranking California Counties for Ability to Obtain Physicians' Services

County Name	Rank by[a] IMU	Claims per Eligible	Hybrid Index
Alameda	36	42	43
Alpine	2	1	1
Amador	46	28	10
Butte	32	49	37
Calaveras	23	3	12
Colusa	20	26	21
Contra Costa	54	19	54
Del Norte	12	10	15
El Dorado	31	16	29
Fresno	21	31	30
Glenn	4	5	7
Humboldt	27	41	26
Imperial	11	40	14
Inyo	25	24	17
Kern	26	35	35
Kings	8	44	13
Lake	5	25	6
Lassen	18	12	20
Los Angeles	37	48	47
Madera	3	11	4
Marin	56	58	55
Mariposa	13	37	9
Mendocino	33	52	25
Merced	10	18	16
Modoc	1	27	2
Mono	14	2	8
Monterey	44	32	42
Napa	53	54	46
Nevada	40	50	24
Orange	55	46	56
Placer	47	33	32
Plumas	15	17	19
Riverside	28	39	38
Sacramento	52	38	51
San Benito	6	9	11
San Bernadino	39	14	48
San Diego	45	53	50
San Francisco	34	57	33
San Joaquin	41	23	49
San Luis Obispo	38	55	44
San Mateo	58	34	58
Santa Barbara	50	45	52
Santa Clara	57	36	57
Santa Cruz	24	56	34
Shasta	49	21	40
Sierra	7	6	3
Siskiyou	19	30	18
Solano	22	51	31
Sonoma	42	47	41
Stanislaus	29	43	39
Sutter	35	8	36
Tehama	30	7	28
Trinity	9	4	5
Tulare	16	15	23
Tuolomne	48	29	22
Ventura	51	22	53
Yolo	43	13	45
Yuba	17	20	27

[a] In case of ties, ranks have been randomly assigned to avoid spurious correlation due to alphabetic ordering.

0.87. The correlation with claims per eligible is 0.50. Seventy-six percent of the counties that were below the median on the IMU are also in the lower half with the hybrid index. For the lower quartile the rankings share 86% of the counties. Compared to claims per eligible, the hybrid also retains 76% of the counties below the median but keeps 57% of the lower quartile counties. In a policy context rankings are substantially different between the first and third columns, as one-fourth of the counties below the median (seven counties) change between columns.

The hybrid index is an apparent solution to the problem of special barriers to physicians' services associated with rurality and race. More or less weight can be given to the objective evidence as seems appropriate. There are, however, a number of cautions that must be observed. Most obviously, the proportional adjustments require that differences in utilization reflect barriers rather than tastes and that the entire target group be affected by factors associated with rurality and race in the same (or at least approximately the same) proportion as Medi-Cal eligibles. Neither assumption is self-evident or established by empirical evidence. Use of the hybrid index depends on a judgment that the assumptions are reasonable.

A less obvious consideration, but one that is crucial, is that proportional adjustment requires the IMU to be on a ratio scale.[10] The techniques used to construct the index permit the presumption of an interval scale. The statistical insignificance of the constants in equations (1) and (2) is consistent with a ratio scale, but more evidence would be necessary to establish it.[11]

Conclusions

The Index of Medical Underservice is a statistically significant predictor of ability to obtain physicians services under California's Medi-Cal program, but it does not predict accurately. In particular, the IMU fails to identify rural and nonwhite persons who are disadvantaged. These findings can be generalized to the entire California population of poor and near poor.

Important federal and state programs use the IMU to locate populations that are disadvantaged in access to physicians' services. More programs will be using an index approach in the future. Bias against rural persons and nonwhites in the index will cause resources to be allocated away from those persons. As a result, the programs may fail to redress the inequities of other allocative mechanisms and to identify many viable practice sites.

A hybrid index was constructed that combines objective information on Medi-Cal utilization with the subjective information of the IMU. Depending on the plausibility of the assumptions involved, the hybrid index will correct for rurality and race and allow comparisons across types of populations. A ranking of counties under the hybrid index shows little overall difference from the IMU ranking, but there is a substantial difference in the lowest quartile counties that are most relevant for policy. Further evidence on the validity of a hybrid index would be useful, since it may provide an operating rule without the biases of the IMU.

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[10] If the IMU is on an interval scale, the error in equations (1) and (2) has a nonzero mean, the coefficient of the IMU times the difference between the arbitrary zero of the interval scale and a meaningful zero. The estimate of the constant term is biased. The estimates of the coefficients still have desirable properties.

[11] Another caution is that the California experience may not be representative of the national experience. For instance, the correlation coefficient between percentage nonwhite and percentage urban is 0.53 for California counties but only 0.18 for the counties of five other states selected randomly. Obviously, the specific equations reported here can not be used in other states.

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An Operational Approach to Multiple Objective Decision Making for Public Water Resources Projects Using Integer Goal Programming

Walter P. Neely, Ronald M. North, and James C. Fortson

Traditional decision-making techniques, such as linear programming, can only optimize one criterion. A variation of linear programming called integer goal programming is proposed as a quantitative approach to integrate multiple objectives in the selection and scheduling of federally funded water resources projects. The deviations from target levels of both economic and environmental objectives may be minimized by using integer goal programming in the evaluation of projects under the proposed multiple objectives. Integer goal programming has the added advantages of permitting decision makers to specify and to change the priorities given each goal and to select only complete rather than partial projects in multiple period funding of multiple objective projects.

The Multiple Objective Problem

The federal water resources project investment decision process has historically maximized one objective, economic efficiency. Recent procedures require that the decision process be extended to at least a second objective, environmental quality. The primary set of objectives recommended by the U.S. Water Resources Council (WRC) and adopted by the Executive Branch include the enhancement of national economic development and the enhancement of the quality of the environment. Other objectives stressed by the WRC are social well-being and regional economic development. However, these two items are recognized only in "accounts" that are believed to be sufficiently included in the encompassing objectives of national economic development and environmental quality (Cicchetti et al., WRC). The four accounts (one quantified and three subjective) provide an effective display of nonmonetary benefits and costs, especially in the subjective areas of environmental quality, social well-being, and regional impact.

The enhancement of national economic development is achieved by "increasing the value of the nation's output of goods and services and improving national economic efficiency" (WRC, p. 24781). Traditionally, this objective was measured using expected economic benefits and estimated costs of resources in terms of dollars (present value basis). The benefit-cost ratio from these estimates was the criterion used by federal agencies to select and recommend projects.

The environmental quality objective is achieved by "the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems" (WRC, p. 24781). Traditionally, this objective has been treated subjectively, if at all. However, the requirement for environmental impact statements under the National Environmental Policy Act for all federal water resources projects has provided the impetus to formulate this objective more quantitatively. The WRC suggests an equal weighting for the two objectives, which requires equivalent quantification and satisfactory rather than maximum solutions.

Goal Programming Methodology

The goal programming (GP) technique, a form of linear programming (LP), has been developed for multiple objective decision making in business by Charnes and Cooper, Ijiri, Mao, and Lee. Applications of the technique in agriculture, forestry, and natural resources have not been widely developed except by Neely, North, and Fortson in water resources. Candler and Boehlje described the application of traditional linear programming to the problem of achieving multiple goals when a preferred goal was subject to specified constraints. However, goal programming allows one to consider multiple goals and to eliminate the unfeasible solutions often obtained through linear programming.

In the GP objective function, one seeks to mini-

Walter P. Neely is an assistant professor in the Department of Business Administration, University of North Carolina at Greensboro, Ronald M. North is an associate director of the Institute of Natural Resources and James C. Fortson is an associate professor in the School of Forest Resources, University of Georgia.

mize the deviation from the goals. Goal programming requires only striving to attain the goal (i.e., "satisficing"), not constraining the solution to the achievement of the goal. The GP objective function may be described as follows: $\min z = \sum_i w_i^+ y_i^+ + \sum_i w_i^- y_i^-$, where y_i^+ is the deviation above (overachievement of) the ith specified goal level and y_i^- is the deviation below (underachievement of) the ith specified goal level for each goal. The w_i^+ and w_i^- are penalties or weights attached to the goal deviations. The goal weights and/or the target goal levels may be used to rank the goals according to the relative importance of each goal.

If all goals are considered equally important, the weights might not be equal because the unit of measure as well as the relative value of each goal might implicitly weight each goal. In order to counter the implicit weighting differences, weight adjustors may be required to equalize the weight assigned to one goal with that of another.

In order to give greater weight to the national economic development goals over the environmental quality goals, the national economic development set of weights would be used. Similarly, environmental quality weights are used when emphasizing that goal. The product of the weight adjustor and the goal level deviation (w^+y^+ or w^-y^-) for more important goals must always be greater than the products corresponding to the less important goals. The goals with higher weights are therefore satisfied in preference to the lower weighted goals. Of course, specifying high target levels for certain goals is similar to assigning high weights, since the products of the weights (w) and the deviations (y) are minimized.

The various goals incorporated in the GP model may be represented by

$$\sum_{j=1}^{m} AI_j X_{ij} + y^- - y^+ = AIG,$$

where AI_j is some goal contribution by project j, X_{ij} is the decision variable or the proportion of project j accepted in period i, and AIG is the goal level for goal AI.

In addition to the goals there may also be several environmental constraints in the GP model. Budgetary constraints may be represented in the GP model in the same form as in an LP model, or they may be represented as goals. Similarly, the integer constraints are implicit for the integer programming (IP) model summarized in table 1. The IP variant eliminates the problem of partial project completions under conditions of annual budget limitations and new project introductions into the portfolio.[1]

The Empirical Analysis of Multiple Objectives

The data used to test the GP technique were the benefit-cost data prepared by the Tennessee Valley Authority (TVA) for their water resources projects for 1965–73. Benefits were calculated by TVA ac-

[1] When integer constraints were not imposed, almost every accepted project was either spread intermittently over several years or only partially completed. Although the GP-IP solution eliminated the fractional projects, it greatly increased computational time due to the large number of integer variables (220). The solutions, the project portfolio, and construction schedule were changed significantly when the GP-IP method was used. In order to obtain an optimum or near optimum solution, the computer processing unit time on an IBM 360-65 system was approximately one hour. The program used was the IBM program product MPSX-MIP, which utilizes a branch and bound algorithm.

Table 1. The GP Problem Matrix for Budget Constraints, Goal Weights, and Goal Levels

	Projects by Years					Carryover of Funds				Goal Programming y^+ and y^- Variables				Equality or Inequality	Budgets and Goal Levels	
	S65	S66	S67	. . .	TF73	CO65	CO66	. . .	CO77	EXP+	EXP−	. . .	RM−		Actual	Planning
Goal	0	0	0	. . .	0					Deviation × Weight 1	1	. . .	1		Objective Function	
1965	1.0					1								≤	0.218	2.0
1966	0.2	1.0				−1	1							≤	7.165	2.0
1967		0.2	1.0	.			−1	.						≤	18.281	5.0
.				. .				. .						.	.	.
.		Annual		. . .				. . .						.	.	.
.		Capital		. .				. .						.	.	.
1977		Expenditures		.	8.5			.	1					≤	5.0	5.0
S1	1	1	1	.										≤	1	1
.				. .										.	.	.
.		Unity		. . .										.	.	.
.		Constraints		. .										.	.	.
TFI				.	1									≤	1	1
EXP	0.02	0.02	0.02	. . .	0					−1	1	.		=	1.09	1.09
.		Goal			.							. .		.	.	.
.		Contributions			.							. . .		.	.	.
.					.							. .		.	.	.
RM	0.03	0.03	0.03	. . .	34							.	1	=	226	226

Table 2. Annual Portfolios Selected When Goal Weights are Equal and Goal Levels Favor Either National Economic Development (NED) or Environmental Quality (EQ)

Fiscal Year	Portfolio of Projects When the Goal Level Favors	
	NED	EQ
1965	—	—
1966	—	—
1967	Sevierville Bear (B) North Fork (U) Swannanoa (U) Mills (U) Little (U)	Bear (B) North Fork (U) West Fork (U) Mud (U) Mills (U) Little (U)
1968	Oliver Mud (U)	Ivy (u)
1969	Normandy (D) Ivy (U)	Cedar (B) Normandy (D) Oliver
1970	East Fork (U)	—
1971	—	S. Chickamauga
1972	—	—
1973	Cedar (B) Tellico	— —
1974	—	Tellico
1975	Levees (U)	East Fork (U) Levees (U)

Note: Perfect foresight of projects, a 3-1/4% discount rate, and the actual budget are assumed in the GP-IP model. (U), (B) and (D) indicate, respectively, a unit project in the Upper French Broad River, the Bear, and the Duck system projects.

cording to accepted procedures. Projects that were predominantly for power were excluded from this analysis (Neely).

The budget levels for the 1965–73 planning period constitute a set of economic constraints that must be satisfied. The budget level for each year tends to be a binding constraint for the programming model. While the budget level may be predicted with some accuracy, any unpredictability of the budget level does not detract from the validity of the GP technique as a decision-making aid.

The final data assumption necessary to make the model operational deals with the appropriate discount rate. During the planning horizon (1965–73) the WRC discount rate rose from 3-1/8% to 6-7/8% (WRC, p. 24822). While different discount rate assumptions were tested, the 3-1/4% rate, under which most of these projects were originally evaluated, was used in this study to avoid any bias resulting from variances in the discount rate.

There are two goal assumptions necessary to make the GP model operational. Goal weights and goal levels must be specified for each goal. Goal weights for each component are required to give greater priority or to equalize priority for each component goal such as net present value, hydroelectric power, water quality, etc. Each of the objectives, and therefore each of the goals, is initially weighted equally by the weight adjustors to comply with the implicit WRC suggestion of equality (WRC).

The goal level assumption is critical to the final solution and is a policy decision relating to the amount or level of each goal. Each goal level must be specified with care because the set of specifications may be as important as the budget level forecast. An appropriate set of goal levels as well as goal weights may be approximated subjectively by an agency, by experienced professionals, or by a political process. The requirements of specifying goal levels and weights is a weak point in the goal programming method. However, this specification of goals is implicitly accomplished in the present decision process without the advantage of organized data. Goal programming forces an explicit consideration of each goal and puts that goal level and weight into a quantitative framework.

The effects of assigning equal weights to the national economic development and environmental quality objectives are reflected in the differences in the projects selected in the portfolio (table 2). The goal levels assumed favor either the national economic development or the environmental quality

Table 3. Annual Portfolios Selected When the Goal Levels and Goal Weights Favor Either National Economic Development (NED) or Environmental Quality (EQ)

Fiscal Year	Portfolio of Projects When Goal Level and Weights Favor	
	NED	EQ
1965	—	
1966	Sevierville Coeburn	— —
1967	North Fork (U) Swannanoa (U) Devils (U) Mills (U) Little (U)	Bear (B) North Fork (U) S. Hominy (U) Mills (U) Devils (U) Mud (U) Ivy (U) Hooper (U)
1968	Bear (B) East Fork (U) West Fork (U) Oliver	East Fork (U) Clear (U)
1969	Normandy (D)	Cedar (B) Normandy (D)
1970	—	Swannanoa (U) Boylston (U)
1971	—	—
1972	—	Cane (U)
1973	Tims Ford Tellico	Little (U)
1974	—	Tellico
1975	Ivy (U)	—

Note: Perfect foresight of projects, the actual budget, and 3-1/4% discount rate are assumed in the GP-IP model. (U), (B) and (D) indicate, respectively, a unit project in the Upper French Broad River, the Bear, and the Duck system projects.

Table 4. A Comparison of the Actual Projects Selected by the TVA and Those Selected by the IP and the GP-IP Models

Fiscal Year	Actual Projects Selected by TVA[a]	Portfolio Projects Selected in the IP Model (Maximize Net Present Value)[b]	Portfolio Projects Selected in the Equal Weight, National Economic Development Preferred Goal Level, GP-IP Model (Minimize Goal Deviation)[d]
1965	Tims Ford	—	
1966	Sevierville	Sevierville	—
	Coeburn	—	—
1967	Tellico	Bear (B)	Sevierville
	Bear (B)	North Fork (U)	Bear (B)
		Swannanoa (U)	North Fork (U)
		Little (U)	Swannanoa (U)
		Channels (U)	Mills (U)
			Little (U)
1968	Oliver	Oliver	Oliver
			Mud (U)
1969	—	Normandy (D)	Normandy (D)
			Ivy (U)
1970	—	—	East Fork (U)
1971	—	Tellico	—
1972	Normandy (D)	Columbia (D)	—
1973	—	—	Cedar (B)
			Tellico
1974[c]	Columbia (D)	—	—
	Little Bear (B)	—	—
1975[c]	Cedar (B)	—	Levees (U)
	Upper Bear (B)	—	—
NPV (mil. $)	73.78	106.77	92.11

Note: Perfect foresight of projects, the actual budget, and a 3-1/4% discount rate are assumed for the 1967–77 planning period. (U), (B) and (D) refer, respectively, to the project units of the Upper French Broad River, the Bear, and the Duck system projects. Project columns 1 and 3 correspond to data columns 1 and 3 of table 5.

[a] The portfolios selected by the programming approaches fully utilize the budget including that proposed for 1974–77, while the actual projects selected leave a credit balance of $0.983 million based on original costs.

[b] The goal level was $105 million for the net present value goal. The other levels (specified and attained) are shown in table 5.

[c] The "actual" projects for 1974–75 are proposed by the TVA to occur during those years.

[d] Integer optimum not proven due to extended computer processing unit times; result is infinitely near optimum.

objective in each respective column. The most significant result of the differences between goal levels is in the timing of project selection. Many of the same projects were chosen under each preferred level. However, different construction schedules were suggested for the different goal level preferences, national economic development or environmental quality (tables 2 and 3).

The effects of giving either national economic development or environmental quality greater weight instead of equal weight are shown in table 3 for both preferred goal levels. The national economic development preferred (weight and goal level) portfolio contained projects concentrated in the early years of the planning period, while the environmental quality preferred portfolio was more evenly distributed over time. The latter emphasized the Upper French Broad River (UFBR) project with thirteen of the sixteen proposed units selected.[2] Only eight proposed UFBR units were chosen in the national economic development preferred portfolio. The large Tims Ford project was absent from the environmental quality portfolio but included in the other. Different goal priorities or different goal levels result in very different portfolios and/or project schedules. Such divergent results from varying the goal levels point out the great need to use the GP-IP technique or an equivalent method to integrate multiple objectives into the water resources project planning and decision-making process.

The differences in the specifications of a weighted objective (for either national economic development or environmental quality) and the specification of equal weight may be examined by comparing the corresponding columns of tables 2 and 3. The resulting portfolio net present value was about $98.5 million when national economic development was weighted greater than environmental quality (assum-

[2] The problem of sequencing multiunit projects was not treated because the data were insufficient in this regard. While the projects selected might change if Krutilla's or Morin's methods of one-dimensional sequencing with discrete discount rates had been utilized, the validity of the goal programming approach remains unchanged.

Table 5. Goal Levels Actually Attained, Specified, and Attained by the Model Using the Goal Programming Approach

Objective/Goal	Actual Level Attained by TVA	National Economic Development Specified Goal Level	Goal Level Attained With GP-IP Model[d]
		Million $[a]	
National economic development			
Net present value[b]	73.780	105.00	92.110
Power[b]	0.552	0.28	0.380
Power (kilowatts)[b]	264.000	200.00	200.000
Navigation	0	0.50	0.531
Flood control	1.763	2.50	2.502
Regional economic development			
Redevelopment[b]	0.113	0.05	0.239
Expansion[b]	1.616	1.00	1.099
Increased land values	0.123	0.10	0.105
Prevented flood damage	0.194	0.15	0.168
Shoreline development	1.127	1.00	1.062
Recreation (mil. user days)[b]	2.606	2.00	2.189
Water supply	1.000	0.80	0.745
Quality of the environment			
Area inundated (acres)	51,310.000	35,000.00	28,079.900
River miles lost (miles)[c]	197.200	266.00	111.350
Reservoir shoreline (miles)	1,105.000	687.00	601.000
Water supply[b]	0.386	0.60	0.996
Fish and wildlife[b]	0.501	0.40	0.372

Note: Planning report knowledge, the actual budget, NED preferred goal levels, and equal goal weights are assumed. Data columns 1 and 3 correspond to project columns 1 and 3 of table 4.

[a] Except as otherwise specified.

[b] Overachievement in these goals was not penalized (GP-IP).

[c] Underachievement in river miles lost was not penalized (GP-IP).

[d] Integer optimum not proven due to extended computer processing unit times, but result is infinitely near optimum.

ing the former's goal levels). When both shared equal weight (assuming national economic development goal levels), the resulting net present value was about $92.1 million. The national economic development preferred (by goal weight and level) portfolio included the large Tims Ford project, while the equally weighted (by goal weight) portfolio contained the smaller Cedar unit of the Bear project. There are significant differences between the portfolios chosen in this GP-IP model and those actually chosen by TVA. Aside from the differences in projects and project schedules, a very striking difference is the lower portfolio net present value that resulted between the actual selection of projects using the present benefit-cost ratio method and the proposed portfolios. The actual selection of projects resulted in a loss of net present value of over $20 million compared with a GP-IP portfolio for projects selected during this period. This comparison of the actual projects selected by the TVA with the projects selected by the GP-IP approach suggests the superiority of the proposed method in future project planning decisions for optimization of both national economic development and environmental quality objectives (table 4).

Other differences between goal attainment may be examined from data in table 5. The national economic development goal levels are shown in the second data column, while the goal levels attained using GP-IP are shown in the third data column. The actual levels attained are shown in data column 1. Note the differences between the TVA actual results and the GP-IP results in the environmental quality goals of area inundated and water quality. The national economic development goals of net present value and flood control provide additional examples. The very significant differences between data column 1 and data columns 2 and 3 suggest that even assuming a variance between the goal levels specified for this research and the actual (implicit) goal levels specified (and achieved) the GP-IP approach appears to be superior to the present subjective decision approach.[3]

The use of the goal programming approach enabled the selection of a combination of projects from which most of the goals are higher than the actual levels. Not only do those with decision inputs have

[3] Regional economic development goals were also included in the model but given lower priority (Cicchetti et al.).

difficulty in selecting goals and calculating trade-offs, but the current complexities in decision making may lead to relatively low benefits on all fronts. By systematically considering the alternatives through formal programming, these undesirable consequences may be minimized.

Summary

The goal programming method provides a basis for an operational approach to multiple objective decision making. The best indicator of the value of the proposed goal programming approach is to test and develop it on a regional or even on a national basis for each construction agency or for the total of all water resources budgets. Such tests can provide practical suggestions of the expected economic, environmental, and social benefits and costs of decisions regarding the selection of projects for funding and construction.

While there are many other factors that could have affected the actual choices of projects (especially political motivations, lack of information regarding future investment opportunities, and budget uncertainties), the GP-IP model could have improved the decision-making process. The goal programming approach is capable of incorporating environmental, regional economic, and national economic factors. Political factors and other qualitative parameters of a social and environmental nature can be built into the model as constraints or as additional goals. The capacity to make trade-offs for different goals in the GP-IP model and to observe the changes in costs, benefits, and net values that result makes this model a powerful decision-making tool in the water resources project selection processes.

To improve the effectiveness of the goal programming technique, significant improvements in both measurement methods and parameter estimation are required. The specification of goal weights and levels is also of great importance to the outcome using the GP-IP approach. Sensitivity analysis may be used to determine the effects of various goal weights. Goal levels may be better estimated through the use of parametric programming. The GP-IP approach offers significant potential for future research and practice as long as improvement of the multiple objectives for planning and evaluating water resources investments remains a viable policy.

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Farmers' Expectations, Risk Aversion, and Market Equilibrium under Risk

P. B. R. Hazell and P. L. Scandizzo

Hazell and Scandizzo (1975) have argued that, when production is risky, competitive markets may no longer be socially efficient and important welfare gains may be obtained through policies aimed at optimally distorting market prices and quantities from their equilibrium values. Newbery has since shown, however, that these results stem in large part from the assumption that farmers base their decisions each year on anticipated prices formed independently of anticipations about yield.

The purposes of this paper are threefold: (*a*) to show that farmers may hold rational expectations in the Muthian sense if they make direct forecasts of revenue per acre (instead of separate price and yield forecasts); (*b*) to show how, if rational expectations are assumed, competitive market equilibria can be simulated in sectorwide mathematical programming models; and (*c*) to illustrate these results with a linear programming model of agricultural production at a subsector level in Mexico.

Rational Expectations and Market Equilibrium

Consider the following market structure:

(1) Demand function: $D_t = a - bP_t$,

(2) Supply function: $S_t = \frac{\lambda}{\mu}\epsilon_t R_t^*$,

(3) Market clearing condition: $D_t = S_t$,

and $E(\epsilon_t) = \mu$, $V(\epsilon_t) = \sigma^2$, and $E(\epsilon_t \epsilon_{t-1}) = 0$ for all t, where R_t^* is the per acre revenue anticipated by producers at the time of making production decisions, P_t is market clearing price, ϵ_t is stochastic yield with mean μ and variance σ^2, and a, b and λ are positive constants.

Let R_t^* initially be set as the naive forecast in which producers simply project last year's per acre revenue, $R_t^* = P_{t-1}\epsilon_{t-1}$; that is, a naive cobweb model, but one defined in revenue rather than in price. Despite this simple formulation, R_t^* is nevertheless a rational expectation in that it maximizes the expected value of realized (*ex post*) consumer's and producers' surplus.

To show this, first solve for the market clearing price P_t:

$$P_t = \frac{a}{b} - \frac{\lambda}{b\mu}\epsilon_t(P_{t-1}\epsilon_{t-1}). \tag{4}$$

Multiplying through by ϵ_t and taking expectations yields

$$E(P_t\epsilon_t) = \frac{a\mu}{b} - \frac{\lambda\mu_2}{b\mu}E(P_{t-1}\epsilon_{t-1}), \tag{5}$$

where μ_2 is the second moment of ϵ around zero.

The market will converge to an equilibrium in mean price if $E(R_t^*) = E(P_t\epsilon_t)$ converges. Using equation (5), if $E(P_t\epsilon_t)$ converges, then the limiting value is[1]

$$\lim_{t\to\infty} E(P_t\epsilon_t) = \frac{a\mu^2}{b\mu + \lambda\mu_2}. \tag{6}$$

Using equation (6) and taking the limit of the expected value of equation (4), one obtains

$$\lim_{t\to\infty} E(P_t) = \frac{a(b\mu + \lambda\sigma^2)}{b(b\mu + \lambda\mu_2)}, \tag{7}$$

which is the value of expected market clearing price in equilibrium and is identical to the expected market clearing price in Hazell and Scandizzo's optimally distorted market (1975, equation (12)).

This simple example can easily be generalized to weighted linear lagged forecasts of per acre revenue. The key result still holds that revenue expectations, unlike price expectations, are rational in the sense that they lead to a market equilibrium in which social welfare is maximum. Of course, which of the two types of expectations behavior is most relevant is a purely empirical question and one that has not been specifically addressed in the literature. Conventional wisdom among economists tends to support the price forecasting model, in which case competitive markets are not efficient. But, to the extent that

P. B. R. Hazell and P. L. Scandizzo are economists in the Development Research Center, International Bank for Reconstruction and Development, Washington, D.C.

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[1] This value has a direct relationship to the optimal anticipated price $E(P^*)$ obtained by Hazell and Scandizzo (their equation (12)). In fact, $E(P^*) = \lim E(P_t\epsilon_t)/\mu$. This is the price that farmers should anticipate if social welfare is to be maximum.

individual yields and prices are negatively correlated and farmers do or can be persuaded to use revenue expectations, the need for market intervention policies diminishes.

Mathematical Programming Models of Market Equilibrium

An increasing number of formal agricultural sector models are now being built using mathematical programming techniques. Many of these models are also structured to provide the perfect competition solution to all product markets when both prices and quantities are endogenous. As such, these models are necessarily premised upon assumptions about the underlying nature of farmers' expectations and market behavior, and the results of the previous section raise interesting questions about appropriate model specification when production is risky.

To illustrate the approach, consider a simple model of annual crop production based on a single aggregate farm facing the linear demand structure $P = A - BWX$. Assuming risk averse behavior of the mean standard deviation type, the quadratic programming formulation of the model maximand can be written as[2]

$$(8) \quad \max \Pi = X'W(A - 0.5BWX) - C'X - \phi(X'\Gamma X)^{1/2},$$

where X is an $n \times 1$ vector of crop acreages grown, W is an $n \times n$ diagonal matrix of crop yields per acre, C is an $n \times 1$ vector of costs per acre, A and B are $n \times 1$ and $n \times n$ matrices of demand coefficients, respectively, Γ is an $n \times n$ covariance matrix of crop revenues (price times quantity), and ϕ is a suitable average of individual farmers risk aversion parameters.

Hazell and Scandizzo (1974) show that the market equilibria simulated by this model maximand correspond exactly to the competitive equilibria that would be arrived at if production is lagged and farmers act on the basis of price expectations. Such market equilibria are inefficient when social welfare is measured as the sum of expected values of the realized (*ex post*) consumers' and producers' surplus. Thus, while equation (8) is the correct model maximand for simulating competitive market equilibria given underlying price expectations behavior, it is not the appropriate maximand when farmers act on the basis of revenue expectations. In fact, given the results of the previous section, the appropriate model maximand for revenue expectations behavior must be the maximand that also gives the optimally distorted solutions to all markets. This maximand is the sum of expected values of the realized (*ex post*) consumers' and producers' surplus.

[2] The maximand requires that the demand matrix B be symmetric.

Algebraically, the appropriate maximand for the sector model becomes

$$(9) \quad \max E(SW) = E[X'N(A - 0.5BNX)] - C'X - \phi(X'\Gamma X)^{1/2},$$

where N denotes the diagonal matrix of stochastic yields such that $E(N) = W$. This maximand differs from equation (8) in that the first term, $E[X'N(A - 0.5BNX)]$, is the expected value of the sum of the areas under the demand curves. Comparing equations (9) and (8), it is evident that the two maximands differ only by the term

$$(10) \quad 0.5X'V(NBN)X = 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_{ij} b_{ij},$$

where $V(NBN) = E(NBN) - WBW$ is a variance-covariance matrix of weighted yields with ijth element $\sigma_{ij} b_{ij}$, and σ_{ij} denotes the covariance of yields between crops i and j, and b_{ij} denotes the cross-demand coefficient. Given that equation (9) is accepted as a useful welfare function, this term is a direct measure of the social costs of market inefficiency (and hence the gain from government intervention) that arises when farmers plan on the basis of price rather than revenue expectations.

The maximand defined in equation (10) does, in fact, provide the solution corresponding to the competitive market equilibria that would be attained if farmers planned on the basis of revenue expectations. Let the constraint set over which equation (9) is maximized be linear, and denote it by $DX \leq b$. Then, the Lagrangian for the problem is

$$(11) \quad L = X'WA - 0.5X'E(NBN)X - C'X - \phi(X'\Gamma X)^{1/2} + v'(b - DX),$$

where v is a vector of dual values. Apart from the feasibility conditions $DX \leq b$, the necessary Kuhn-Tucker conditions imply

$$(12) \quad WA - E(NBN)X \leq C + \phi\Gamma X(X'\Gamma X)^{-1/2} + D'v.$$

From the assumed demand structure, the vector of market clearing prices in any one year is $P = A - BNX$. Multiplying by the diagonal matrix of yields N, the vector of per acre revenues R is then $R = NP = NA - NBNX$. Taking the expected value, $E(R) = WA - E(NBN)X$. But this is the left-hand side of equation (12), so that at optimality expected revenue per acre must be equal to or less than marginal cost for each activity. Complementary slackness conditions require that equation (12) hold as a strict equality for all nonzero X_j, in which case expected marginal revenue equals marginal cost at optimality.

The optimal solution is the required market solution if farmers equate expected marginal revenue with marginal cost at equilibrium. Given $E(y) - \phi S(y)$ utility, and revenue expectations R^* that, at

equilibrium, satisfy $E(R^*) = E(R)$, then the appropriate farm planning problem is max $U = E(R)'X - C'X - \phi(X'TX)^{1/2}$ subject to a set of linear resource constraints that are again denoted by $DX \leq b$. It is a trivial task to show that the necessary Kuhn-Tucker conditions for this problem lead to the same result as in equation (12) and that complementary slackness conditions again require that expected marginal revenue equals marginal cost for all nonzero X_j.

An Illustrative Application in Mexico

An agricultural sector model (CHAC) already exists in Mexico (Duloy and Norton 1973) and provides a suitable basis for comparing the equilibrium effects of price versus revenue expectations behavior. CHAC is a linear programming model that encompasses the supply—domestic and imported—and all demands—domestic and export—for thirty-three short-cycle crops. It does not include livestock, forestry, or long-cycle crops. The model is an aggregate of regional submodels, which are linked through a national market structure (domestic and foreign) and by some common resource constraints. CHAC is a static equilibrium model and provides the perfect competition solution to all markets for both prices and quantities through use of the kind of maximand detailed in equation (8) under the assumption that farmers are, on the average, risk neutral ($\phi = 0$).

To keep this study within manageable limits, a smaller version of CHAC was created that includes only selected areas of irrigated land. These selected areas represent eight of the more than one hundred administrative districts of the Mexican Ministry of Water Resources. They are not contiguous districts but are scattered throughout the arid agricultural areas of Mexico. The Pacific Northeast area includes the districts of Culiacan, Comision del Fuerte, Guasave, Rio Mayo, and Santo Domingo. The North Central area includes the Ciudad Delicias and La Laguna districts, while the Northeast area includes only the Bajo Rio San Juan district. Taken together, the eight districts account for significant shares of the national production of cotton, tomatoes, dry alfalfa, rice, soybeans, and safflower (see table 1). The average district cropping patterns for the years 1967–68 to 1969–70 are given in table 1 and exclude a small percentage of land devoted to crops that are not included in the models. Crop production is almost entirely dependent on irrigation in all eight districts, and any small areas of rainfed land have been excluded.

In total, the eight district models cover 99,000 farms of an average size of 5.8 hectares (table 1). For modeling purposes, each district is treated as a single large farm. The farms are thought to be sufficiently homogeneous so that this procedure is unlikely to lead to any serious aggregation bias. The model's activities provide for the production, in each district, of the crops grown by that district, each with a choice of three mechanization levels and two planting dates. A set of labor activities provides flexibility in selecting seasonal combinations of family and hired day labor. Family labor is charged a reservation wage of one-half of the hired day labor rate. Purchasing activities provide for the supplies of

Table 1. Average District Cropping Patterns, 1967–68 to 1969–70 (Harvested Hectares)

Crops	El Fuerte	Culiacan	Rio Mayo	Guasave	Delicias	San Juan	St. Domingo	Laguna	Aggregate	Percentage of National Production
Dry alfalfa	1,988	—	2,144	—	6,510	—	285	5,498	16,425	34
Cotton	46,364	—	15,535	—	7,903	1,190	17,585	67,964	156,541	25
Green alfalfa	—	543	—	—	—	—	—	5,224	5,767	2
Rice	11,335	23,568	—	3,480	—	—	—	—	38,383	25
Sugar cane	12,706	24,172	—	—	—	—	—	—	36,878	12
Safflower	4,790	13,374	10,435	3,737	—	—	1,098	—	33,434	29
Barley	—	—	112	—	—	—	—	—	112	1
Chilies	386	1,570	—	48	—	—	—	—	2,004	9
Beans	16,224	11,024	—	202	—	—	—	—	27,450	3
Chickpeas	561	938	—	271	—	—	—	—	1,770	1
Tomatoes	3,049	9,563	—	581	—	—	—	—	13,193	37
Sesame	3,010	2,815	8,390	144	—	—	—	—	14,359	4
Maize	10,792	4,302	4,071	2,420	10,053	54,269	1,038	6,213	93,158	2
Cantaloupe	231	397	—	722	—	—	—	—	1,340	4
Potatoes	1,320	—	—	—	—	—	—	—	1,320	5
Cucumbers	—	—	—	8	—	—	—	—	8	0
Watermelons	757	325	—	41	—	74	—	—	1,197	5
Sorghum	24,238	22,795	10,616	1,238	7,719	19,876	—	5,592	92,074	11
Soybeans	16,264	4,392	11,886	—	—	—	—	—	32,542	20
Wheat	23,561	3,057	29,969	5,742	29,668	1,048	11,738	16,150	120,933	16
Totals	177,576	122,825	93,158	18,634	61,853	76,457	31,744	106,641	688,888	
Number of farms	16,484	6,224	9,185	2,984	10,710	4,480	647	48,341	99,055	
Available hectares per farm	10	12	8	6	4	16	47	2	5.8	

Note: Seeded hectares include significant amounts of double cropping in most districts.

Table 2. Price Solutions for the Price Expectations Model with Various ϕ Values (Pesos per Ton)

	Values of ϕ					Base Period Actuals	Group Own-Price Elasticity
	0	0.5	1.0	1.5	2.0		
Sugar cane	68	68	70	68	69	70	−0.25
Tomatoes	330	705	1,071	1,319	1,636	1,150	−0.4
Chilies	700	741	748	828	965	1,500	−0.2
Cotton fiber	5,770	5,770	5,770	5,770	5,770	5,770	−0.5
Dry alfalfa	308	347	442	485	498	400	
Green alfalfa	75	69	64	63	62	100	
Barley	848	787	793	806	801	930	
Chickpeas	1,725	1,673	1,631	1,818	1,987	990	−0.3
Maize	1,044	981	1,023	1,106	1,128	860	
Sorghum	557	568	549	533	549	630	
Rice	1,195	1,101	1,047	1.035	1,038	1,220	
Beans	2,334	2,179	2,091	2,053	2,040	1,830	
Chickpeas	1,725	1,673	1,631	1,818	1,987	990	−0.3
Potatoes	391	468	537	699	882	930	
Maize	1,044	981	1,023	1,106	1,128	860	−0.1
Wheat	971	912	905	935	959	800	
Cantaloupe	329	488	705	935	928	680	−2.0
Watermelons	297	291	260	299	280	780	
Safflower	1,550	1,401	1,391	1,484	1,509	1,550	
Sesame	3,444	3,384	3,151	3,000	2,989	2,410	−1.2
Cotton oil	651	690	796	1,047	1,206	830	
Soybeans	1,382	1,364	1,356	1,422	1,466	1,600	
Cucumbers	569	681	838	790	317	590	−0.6
Social welfare (billions of pesos)	4.21	4.04	3.97	3.83	3.83		

mules, machinery, and irrigation water. Seasonal constraints are imposed on land and labor, and an annual constraint is imposed on water supplies. Technical coefficients and costs are taken at 1967–68 to 1969–70 average levels. The model's constraints are also based on this period. Average yields are based on the six-year period 1966–67 to 1971–72, and risk parameters were estimated from time-series data spanning the period 1961–62 to 1970–71.

The district models are linked in block diagonal form and integrated into an aggregate market structure, similar to that in CHAC; that is, the market comprises linear domestic demand functions of the form $P = A - BWX$ and has import and export possibilities at fixed prices.[3] The domestic demand curves have the same national price elasticities as in CHAC but are located at mean output levels appropriate for the eight district aggregates. Export and import constraints are also prorated according to the ratio of output from the eight districts to national output for each product. Finally, the model structure was changed from that of CHAC by introducing risk averse behavior. More specifically, farmers are assumed to maximize $E(y) - \phi S(y)$ utility.

The resultant model was solved for competitive equilibria solutions to all product markets corresponding to price and then revenue expectations behavior. This was achieved by using the two maximands defined in equations (8) and (9).[4] In both cases, the aggregate risk aversion parameter ϕ was varied in order to evaluate the effects of different levels of risk averse behavior on the model's solutions.

Tables 2 and 3 show the domestic price solutions to the two models for different values of ϕ. These values are the expected market clearing prices in equilibrium and are obtained as dual values from the model solutions. Since there is obviously a one-to-one relationship between the market prices and the total production of each crop sold in the domestic market, differences between price solutions also reflect differences in production.

In general, the revenue expectations model leads to higher domestic prices and, hence, to lower production for the domestic market. This effect is particularly pronounced in the case of chilies, while wheat and maize provide the only significant excep-

[3] To approximate cross-elasticity relationships in demand, the crops are classified into demand independent groups (see tables 2 and 3), and linear substitution is allowed between products within each group as rates fixed by average 1967–68 to 1969–70 relative prices. For a more detailed description, see Duloy and Norton (1973, 1975).

[4] In both cases solutions were obtained through linear programming, using the linearization techniques of Duloy and Norton (1973, 1975), and Hazell (1971).

Table 3. Price Solutions for the Revenue Expectations Model with Various ϕ Values (Pesos per Ton)

	Values of ϕ					Base Period Actuals
	0	0.5	1.0	1.5	2.0	
Sugar cane	75	73	74	73	74	70
Tomatoes	428	756	1,150	1,387	1,729	1,150
Chilies	2,927	2,980	3,071	3,233	3,380	1,500
Cotton fibre	5,770	5,770	5,770	5,770	5,770	5,770
Dry alfalfa	492	465	467	459	472	400
Green alfalfa	139	103	90	88	90	100
Barley	860	791	776	742	761	930
Chickpeas	1,725	1,595	1,535	1,588	1,720	990
Maize	1,011	957	1,016	1,000	1,036	860
Sorghum	605	546	505	515	542	630
Rice	1,424	1,377	1,322	1,247	1,256	1,220
Beans	2,259	2,082	2,023	1,929	1,992	1,830
Chickpeas	2,063	2,106	2,068	2,105	2,218	990
Potatoes	1,900	2,341	2,241	2,216	2,296	930
Maize	1,027	1,011	1,045	1,079	1,132	860
Wheat	955	899	899	896	909	800
Cantaloupe	528	749	454	743	734	680
Watermelons	521	499	520	490	463	780
Safflower	1,567	1,494	1,489	1,449	1,451	1,550
Sesame	3,548	3,360	3,043	3,048	3,093	2,410
Cotton oil	747	761	818	1,003	1,171	830
Soybeans	1,495	1,466	1,437	1,477	1,467	1,600
Cucumbers	579	702	291	108	6	590
Social welfare (*billions of pesos*)	4.48	4.27	4.10	3.96	3.85	

tions. This is to be expected, since the solutions to the revenue expectations model correspond to the optimally distorted prices of the Hazell-Scandizzo model. Hazell and Scandizzo (1975) showed, in the single-product case, that the optimal market distortion involves a cutback in production compared with the level in a price expectations equilibrium, with a resultant increase in the expected market clearing price. The results in tables 2 and 3 tend to substantiate this result for the multiproduct case, although the perverse outcomes for wheat and maize demonstrate ambiguities that arise in the multiproduct case from the existence of cross-demand effects and negative correlations in yields.

The bottom lines of tables 2 and 3 show the value of social welfare obtained from the two models for different values of ϕ. Welfare is measured using equation (9), that is, using the expected value of the sum of realized or *ex post* producers' and consumers' surplus. This value was obtained directly from the objective function for the revenue expectations model but had to be calculated from the solution to the price expectations model.

These results demonstrate the superiority of market equilibria associated with revenue expectations behavior. For $\phi = 0$, for example, welfare is 270 million pesos greater when farmers plan on the basis of revenue rather than price expectations. Since it can be shown that the social gain accrues entirely to producers (Hazell and Scandizzo 1975), this amount is equivalent to an average gain of about 2,700 pesos (U.S. $200) per farm.

The difference in welfare between the two sets of solutions diminishes as ϕ increases, suggesting that private risk averse behavior on the part of farmers can adequately offset the shortcomings of price expectations behavior. Indeed, when $\phi = 2.0$, the two models have almost identical welfare outcomes.

Various simple measures of the overall goodness of fit between the different price solutions and the base period actuals were used, including the mean absolute deviation and the correlation and the regression coefficients between the model predictions and the base year prices. These indicators all show that the price expectations model provides a superior fit for all values of ϕ, and its superiority increases monotonically with ϕ as measured by the difference between the mean absolute deviation outcomes. Both models provide their best fit when $\phi = 1.0$, a very plausible value given the underlying $E(y) - \phi S(y)$ utility specification.

Base period trade figures correspond closely to both models for ϕ values of 0 or 0.5. However, for $\phi \geq 1.0$ the price expectations model grossly underestimates the level of sugar exports. The revenue expectations model, on the other hand, retains a relatively good fit.

Conclusions

This paper has demonstrated that alternative assumptions about the way in which farmers form

their price and yield expectations have important consequences for the ensuing market equilibrium when production is risky. In particular, while competitive markets are inefficient if farmers ignore correlations between stochastic prices and yields, they are efficient if such correlations are taken into account. The simplest way in which this can be achieved is for producers to project last year's per acre revenue for each enterprise. This approach can be incorporated in agricultural sector models by using the method presented in this paper. As results from an application at a subsector level in Mexico show, the adoption of this method may cause important differences in the solutions as compared with conventional model formulations.

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Toward a More Meaningful Measure of Firm Growth

Eddy L. LaDue

Research on the time-related characteristics of the firm has frequently been conducted within the context of growth. Growth is also frequently used by business managers as a measure of success over time. A multitude of measures have been used to chart the rate of growth and in most cases the particular measure used appears to be based as much on expediency as on sound reasoning. For researchers to determine optimum growth strategies, or for firm managers to correctly measure their rate of progress and appropriately evaluate business alternatives, an unambiguous comprehensive measure of growth is required.

Optimum firm organization can be defined in terms of the configuration of assets and processes used at a particular time and optimum growth in terms of changes in the configuration through time. An optimum growth path specifies a preferred firm organization in each time period. However, an optimal firm organization determined for any isolated time period is not necessarily consistent with optimum growth. An appropriate measure of growth must accurately reflect progress over a series of time periods.

As commonly measured, the growth rate can be defined as $g = (E/B)^{1/n} - 1$, where g is compound growth rate, E is size of firm at end of growth period, B is size of firm at beginning of growth period, and n is number of years in the growth period. This definition provides a simple approach to determining average growth rates over time and reduces the problem of measuring growth to a question of the appropriate measure of size. Thus, selection of an unambiguous comprehensive measure of growth requires selection of the appropriate measure of size.

The purpose of this paper is to demonstrate the superiority of an appropriately defined wealth measure of size for use in measuring farm growth. The shortcomings of size measures frequently used are identified. The wealth measure of size and a limited information derivative, profit units, are defined. Finally, the proposed measures are evaluated in an empirical example. The wealth measure proposed should be easily adoptable in research situations where net income is available. For empirical studies where net income information is limited, the profit units measure may be more applicable.

Eddy LaDue is an associate professor in the Department of Agricultural Economics, Cornell University.

Shortcomings of Common Size Measures

Commonly used size measures can be categorized as physical and financial measures of input and output. Indexes of inputs are used by both Renborg and Penrose. Penrose uses total investment exclusively, while Renborg uses a more complete but abstract and less tractable vector of resources. Others have used or suggested use of alternate measures of inputs, such as number of cows and number of acres as the appropriate measure of size.

Although input measures provide an easily understood index of size, particularly for extension clientele, they fail to differentiate productive growth from unproductive growth and do not reflect the difference in productive capacity of alternate assets. An increase in number of cows, number of acres, or total investment does not necessarily imply an improvement in income. Furthermore, if cows are a productive investment, some cows will be more productive than others.

Use of a physical inputs measure of size also excludes the financial characteristics of firm growth. This not only eliminates an important firm characteristic from the measure used but also limits the ability to study the increasingly important influences of financial management on the growth process. For example, when a firm experiences an absolute increase in debts greater than the corresponding increase in assets, the growth rate indicated by physical inputs measure of size exaggerates the rate of progress made by the firm. Changes in a firm's liquidity position and credit reserve are not reflected by physical input measures of size.

Only if one is willing to assume productive homogeneity for all resources at all stages of growth is an input approach to growth measurement appropriate. Such an assumption may be plausible for highly aggregated data but represents a severe handicap for individual-firm research.

Output measures of size such as gross sales or total pounds of milk produced are similar to input measures in failing to differentiate productive growth from unproductive size changes. Gross sales per se also contain a livestock or high-value crop bias, as these items frequently have lower profit margins per dollar of sales or investment than low-value crops. Thus, apparent growth can be achieved through enterprise substitution that may indeed provide little or no real improvement in present or future net income flows. Growth rates may also be confused by

cyclical patterns in commodity prices. Although price trends represent a legitimate influence on growth, purely cyclical changes will tend to either accentuate or offset real growth.

Net worth is a frequently used financial measure of size. Change in net worth reflects the increase or decrease in the firm's value over time, a prevalent farm operator goal. However, changes in equity fail to reflect many changes in assets or liabilities that do not immediately affect net worth. A farm business may show little growth over a ten-year period if an investment near the end of that period generates a large capital loss.[1] Although the farm may be in a markedly improved income-generating position, this is not reflected in the growth rate as measured by net worth.

Desired Characteristics of Size Measures

Recognition of multiple managerial goals has prompted investigations of their effects on optimal growth. Although most of these studies have used some version of linear programming, which requires a single objective function, they have found that varying the objective function does imply different optimal growth strategies. Attempts to reflect multiple goals through the single objective function have required use of arbitrary goal weighting and/or decision rules (Candler and Boehlje; Patrick and Eisgruber). The rudimentary nature of economists' ability to handle multiple goals leads to the conclusion that the size measure used must either represent the most important goal or come closest to representing a compendium of a number of goals.

This paper argues that the present value of net income flows over the relevant time horizon represents the most desirable measure of size. Use of this measure recognizes that farms are businesses and that the primary incentive for operation of a business is income or at least long-run profit maximization. Many other goals are natural derivatives of net income; the real value of net worth is the capitalized value of the net returns it can produce. Although some goals may be inconsistent with growth, use of a net income criterion allows determination of trade-offs between goals in terms that firm managers understand.

The real advantage of an income measure of size is its all-inclusive nature. As indicated above, most size measures exclude some important characteristics of the firm that contribute to determination of firm progress. A desirable measure of size should reflect both intensive and extensive growth. Extensive growth involves changes that increase the quantity of resources used, while intensive growth includes those changes in firm organization and operation that increase productivity or efficiency. It has been argued earlier in this paper that the productivity of resources added during extensive growth must be reflected. A useful size measure for determining growth rates should also reflect the income-generating potential of reallocation of existing resources to more efficient use.

It can be argued that intensive growth is just profit maximization through recombination of existing resources. However, when growth is viewed as a process of change over time that is expected to improve the income position of the firm, efficiency changes (intensive growth) must be viewed as a part of that process. Otherwise, what is called growth represents a result of dynamic processes that may or may not be good for the farm ownership and/or management. When efficiency changes are included, use of net income as a size indicator allows growth to become a measure of good in a dynamic analysis in much the same way that profit is a measure of good in a static analysis.

A Wealth Measure of Size

Incorporation of time horizon with the net income approach implies a total wealth measure of size. For some time, the summation of discounted future income streams into perpetuity has been used as a measure of well-being. Its primary use has been at the theoretical level, and it has not generally been used as a measure of firm size.

Numerous studies (including Barry, Barry and Baker, and Boehlje and White) have used the net present value of some combination of annual net income, consumption, and terminal net worth as the objective function. These studies limit net income and consumption considerations to those achieved within a normally arbitrarily chosen growth period and assume that market or book value of assets held at the end of that growth period accurately represents their income-generating capacity.

In general terms a wealth measure of size can be expressed as

$$w = \sum_{j=1}^{\infty} \frac{X_j}{(1+k)^j},$$

where w is firm size at present, X_j is after tax net income for time period j, and k is after tax cost of equity capital.

After tax net income in this case is the net income that the firm would expect if it was operated at its present size (no further growth) in the future; that is, size is indicated by the present value of the income that would be generated if the business were static and operated without organizational change into perpetuity. This assumes that the factors affecting relative real income will remain constant over time and that the debt position remains constant. In most

[1] Farm machinery, specialized buildings, and the family car all frequently sustain capital loss. If one tries to sell them the day after they are purchased, the market value is significantly less than the purchase price or construction cost. This fundamental fact is often not recognized in theoretical analyses, which show that net worth maximization is consistent with profit maximization.

cases, the best estimate of this expected income is indicated by recent income experience. Under deterministic static conditions, one year of data would be sufficient. Under highly variable conditions, a longer time period would be required.

After tax net income for any period of business operation can be calculated as cash income minus cash operating expenses, interest on debt, taxes, and cost of capital maintenance. Cost of capital maintenance is similar in concept to depreciation, except that it has no direct tax implications. It represents the annual capital investment required to maintain the present earnings stream of the business over an extended time period. Actual depreciation amounts from farm business records may be usable in cases where selected useful lives are realistic in terms of the physical asset durability.

Operationally, use of a wealth measure of size requires use of a shorter time period than infinity. The appropriate time horizon depends upon the type of agriculture being studied and other factors. Periods of twenty to thirty years have often been used in growth research. Using the farming horizon of a potential purchaser of the business appears most defendable. Since the primary first-year decision of a potential purchaser is whether to buy the farm, use of the farming horizon is consistent with Boussard's suggestion that the appropriate planning horizon is the time period within which it is necessary to plan in order to make first-period decisions. The value of an operating farm business is the present value of the income stream that a young man could expect to derive from it during his lifetime.

The only modification of the wealth equation required to allow use of a finite investment horizon is inclusion of the terminal value of assets. When discounted back from infinity, the terminal value of assets is zero and can be ignored. With a shorter period, the value of these assets becomes a potentially important contribution to wealth. The new wealth measure of size becomes

$$w = \sum_{j=1}^{n} \frac{X_j}{(1+k)^j} + \frac{A}{(1+k)^n},$$

where n is number of years in discount time period, and A is total firm asset value minus total firm debts (net worth).

When the firm is assumed to be operating under static, no-growth conditions during the entire time period, the terminal value of the assets is equal to their value at the time size is being measured, barring any relative real price changes in asset values. Within the present economic environment, there appears to be little real basis for sustained price changes in any asset group except land. Prices of other assets will likely fluctuate with production and construction costs, but there is no a priori reason to expect change in real value. Alternately, population pressures on available land may provide continued appreciation in land value. Recognition of this factor requires use of a terminal land value that accounts for the appreciation that is expected.

The wealth equation modified to include land appreciation becomes

$$w = \sum_{j=1}^{n} \frac{X_j}{(1+k)^j} + \frac{(A-L) + L(1+a)^n}{(1+k)^n},$$

where L is land value at time size is measured, and a is land appreciation rate. As measured in this manner, present wealth of the farmer as a measure of size accounts for the profitability and efficiency of the firm through net income, the capital structure through interest payments included in the net income calculations and land appreciation plus income beyond the potential planning horizon through the discounted terminal value of assets. Using wealth as the measure of size at the beginning, end, and any selected interim point of the growth period will accurately measure the growth that has occurred.

Profit Units—A Limited Requirements Approach

The primary limitation of the wealth measure of size is that the entire income situation of the firm must be known. Although this may be possible for many cases, it is less appropriate for empirical studies where data on large numbers of actual farm businesses are involved. A measure of size, which is more limited in its data requirements but yet allows maintenance of the net income concept, is profit units. Profit units are essentially an indication of the profit potential of the firm. Each profit unit represents $1 of sustainable estimated profit.

Operationally, this requires determination of the expected profit for each enterprise based on a set of physical criteria that can be used to indicate the likely income potential of the enterprise. Research reports and extension accounting project data provide sources of information from which profit potential of individual enterprises can be estimated. Budgeting of typical farm situations may also provide the required information. The profit units tables for dairy cows, corn silage, and hay in New York for 1971 are shown in tables 1 and 2. Dairy enterprise

Table 1. Profit Units per Cow, 1971

Milk Sold per Cow (Lbs.)	Housing System Type: Stanchion, Under 50 Cows	Stanchion, 50 Cows and Over	Free Stall, Under 100 Cows	Free Stall, 100 Cows and Over
Less than 10,000	—50	—60	—20	0
10,000–11,999	0	0	20	40
12,000–13,999	30	40	50	80
14,000 and over	50	60	90	120

Table 2. Profit Units per Acre for Hay Crop and Corn Silage, 1971

Yield (Tons per Acre)	Acres of Crop		
	Less Than 50	50–99	100 and Over
Hay crop			
Less than 2.0	−15	−5	0
2.0–2.9	0	5	10
3.0 and over	5	10	15
Corn silage			
Less than 12.0	−40	−25	−20
12.0–15.9	−20	−5	0
16 and over	0	15	20

profit units are a function of production level, size of herd, and housing type. Determination of profit units per firm requires summation of the total profit units for all firm enterprises.

Profit, as used in this context, is equal to return on capital and management. The lack of financial data eliminates any consideration of the debt level, and thus the distribution to all capital is included in the residual profit. If financial information were available, it would be possible to specify the debt level, or assume an average equity ratio, and reduce profit to a return to management.

As a measure of size, profit units allow segregation of profitable and unprofitable growth. They are also an immediate reflector of organizational changes designed to improve income. Their primary advantage is the limited individual firm data required for their implementation. They provide some standardization of farms by excluding certain individual firm or manager peculiarities and allowing isolation of general relationships in firm growth that could be hidden by measures more sensitive to specific farm situations. Cyclical price patterns may also be eliminated, which would be particularly useful when different kinds of businesses are being compared.

In addition to their inability to reflect the capital ownership structure of the firm, profit units have the disadvantage of requiring their delineation per unit of each enterprise based on physical data. Although the physical data are easier to observe or generate, the relationships between these factors and expected profit are often not fully known. The profit units measure assumes that the physical data-profit relationships used in developing the profit units tables represent the actual situation for all farms. Thus, the soundness of profit units as a measure of size will be a direct derivative of the accuracy of the physical data-profit relationships used.

Although profit units are obviously a less comprehensive measure than the wealth approach from which they are derived, they maintain the desirable property of including both intensive and extensive growth. The limited data required make profit units particularly applicable for empirical growth studies.

An Illustration

To illustrate certain characteristics of selected size measures, data for a typical northeastern dairy farm were developed indicating alternate sets of operating and financial results of the type that are frequently observed during the growth process (table 3). A 40-cow firm that doubles its herd size over the growth period by duplicating the initial resource base to achieve an exact doubling of resources, receipts, and net income is used as a base for comparison. The other firm growth situations include a doubling of herd size with (*a*) an increase in productivity of animals and land, (*b*) an investment near the end of the growth period that involves a capital loss (expenditures for construction exceeded market value of structure constructed), (*c*) a doubling of all operating data but an increase in the proportion of debt capital, and (*d*) an increase in operating cost rates, possibly reflecting poor management.

Rates of growth for each alternative as indicated by various measures of size were calculated (table 4). For ease in exposition, rates of growth are presented as a percentage of total growth over the period rather than compound annual rates. The benchmark change of doubling business size indicates the expected 100% change for all measures except total cash costs and profit units. The labor supplied by the operator for the first 40 cows must be hired for the added animals, and total cash costs increase more than twofold, although total resources used have exactly doubled. Profit units indicate a larger than 100% increase because they assume that the increased per unit profit normally attendant with the indicated change in herd size (table 1) is achieved.

Most trained observers would agree that doubling size of business and increasing crop and animal productivity or building modern housing structures indicate greater "growth" in the business than doubling herd size alone. Alternatively, they would also agree that doubling herd size while more than doubling outstanding debt or expenses indicates a less improved situation than an exact doubling of all factors. Given this rough ranking of alternatives, one can evaluate the various measures of size. Any violation of this ranking can be taken to indicate failure of a measure to accurately reflect growth.

The resource use measures of size either totally fail to differentiate among the situations indicated or give incorrect indications of appropriate ranking of alternatives. Herd size provides no differentiation. Total investment indicates more growth when new housing facilities are constructed but fails to differentiate among all other alternatives. Total cost does indicate differences among alternatives but rates a doubling of herd with excessive costs above a similar change with controlled costs.

Output measures also fail to differentiate among alternatives. Gross receipts indicate no differences between the alternatives except for a higher rate of growth with increased productivity. The capital loss characteristic of the building alternative causes net

Table 3. Business Evaluation Criteria for Alternative Growth Achievements, Northeast Dairy Farm, Simulated Data

Business Factor	Before Growth	Doubling Business Size	Doubling Business Size Plus: Productivity Increases	Doubling Business Size Plus: Building-Capital Loss[c]	Doubling Business Size Plus: Increased Debt Capital	Doubling Business Size Plus: Excessive Cost Increases
Cows (no.)	40	80	80	80	80	80
Acres of corn	35	70	70	70	70	70
Acres of hay	100	200	200	200	200	200
Total investment ($)	100,000	200,000	200,000	230,000	200,000	200,000
Milk/cow (lbs.)	13,000	13,000	14,000	13,000	13,000	13,000
Corn/acre (tons)	16	16	18	16	16	16
Hay/acre (tons)	2.5	2.5	3.5	2.5	2.5	2.5
Debt ($)	50,000	100,000	100,000	160,000	125,000	100,000
Cash receipts	43,000	86,000	97,000	86,000	86,000	86,000
Cash cost[a]	24,000	56,000[b]	68,000[b]	48,000[d]	56,000[b]	58,500
Capital maintenance	5,000	10,000	10,000	12,000	10,000	10,000
Interest paid	4,000	8,000	8,000	12,000	10,000	8,000
Operator labor and management	8,000	8,000	8,000	8,000	8,000	8,000
Net income	2,000	4,000	5,000	6,200	2,000	1,500
Profit units[e]	2,200	6,250	8,850	7,050	6,250	6,250

[a] Excluding interest.
[b] Includes $8,000 for doubling labor supply.
[c] Construction of $60,000 free stall facility with 50% capital loss.
[d] Reduced labor requirements and costs with new facility.
[e] Calculated using tables 1 and 2 and the physical characteristics listed above.

worth to severely discount the growth achieved for that alternative. Instead of indicating greater growth than with a mere doubling of resources, it indicates less. In fact, net worth rates the alternative with increased debt capital as representing a change similar to construction of new facilities. Net worth is unable to differentiate among the other alternatives.

The ability of profit units to measure the various characteristics related to size depends upon the variables included in the functional relationships developed for determining profit units for each enterprise. Productivity increases and improvement in housing facilities were recognized and properly evaluated (at least in terms of direction of effect). Profit units did not discern the effects of capital structure changes or cost increases. Only the wealth measure was able to appropriately discern those changes that implied a more than doubling of size from those that implied less. Although the alternatives considered here include only one farm type, the wealth measure is well adapted to analysis across different farm types. Size is not tied to any enterprise specific statistic but uses asset, income, and expense items common to all farm types.

Although this illustration has tested only the ability of these size measures to rank alternatives as better or worse than a standard, only the wealth measure stands up under this weak evaluation criterion. An evaluation of the size measures' ability to appropriately indicate relative magnitudes of growth would also be useful. However, such an analysis is difficult to conduct in the absence of a standard

Table 4. Growth Rates Indicated by Alternate Size Criteria, Northeast Dairy Farm, Simulated Data

Size Measures	After Growth With: Doubling Business Size	Productivity Increases	Building-Capital Loss	Increased Debt Capital	Excessive Cost Increases
Number of cows	100	100	100	100	100
Total investment	100	100	130	100	100
Total cash costs	133	183	100	133	144
Gross receipts	100	126	100	100	100
Net worth	100	100	40	50	100
Profit units	184	302	220	184	184
Wealth[a]	100	140	174	10	1

[a] Thirty-year investment horizon, zero land appreciation, and 7% after tax cost of equity capital were assumed.

against which the evaluation can be made. If a perfect measure of growth existed, one would be able to evaluate other measures, and the question of an appropriate measure would be easily solved. While striving for that perfect measure, one should at least use only measures that give appropriate ranking for important observable alternatives.

Summary

Assuming growth research is an appropriate vehicle for study of dynamic processes of the farm firm, an appropriate measure of growth is necessary. The problem of selecting the correct measure of growth can be reduced to a search for an appropriate measure of size. Many of the measures frequently used fail to differentiate between productive and unproductive growth and become inoperable as determinants of optimum growth rates. This demonstrates the need for a size measure that can evaluate and net out firm changes that imply an improvement in the owner-operator income position and those that imply deterioration.

Two measures are proposed that might meet these criteria: wealth and profit units. Profit units have the advantage that the necessary firm data are easier to obtain, some standardization of individual firm data is achieved, and the net income concept is maintained. The wealth measure incorporates projected net income and net worth through discounting. By using net income, it captures all the factors that influence the achieved wealth position of the firm and in essence incorporates most of the other measures of size. It does require complete business and financial data but, as illustrated by example, is superior to commonly used measures in its ability to rank alternative growth situations.

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Another Look at the Hog-Corn Ratio

Karl D. Meilke

The hog-corn price ratio has long been used as a proxy for profits in the pork sector. This statement remains true even though Blosser pointed out a decade ago that the hog-corn price ratio is deficient on at least two grounds: corn is not as important an input in producing hogs as it once was and the same price ratio implies different levels of profitability depending on the level of corn and hog prices.[1] Why has the hog-corn ratio remained a widely used measure of profitability? Part of the answer can be found in the simplicity of the ratio. In addition, the stability of corn (feed) prices over much of the past twenty years meant that the price ratio moved directly with hog prices and that an increase in the ratio implied an increase in profitability. Thus, notwithstanding Blosser's concerns about the relative decline of corn as an input, the hog-corn price ratio apparently was an excellent measure of profitability. During 1970–75, corn prices were more volatile and higher (table 1) than in previous years, suggesting the hypothesis that the hog-corn price ratio would be less useful as a predictor of hog supply since the correlation between hog prices and profitability declines as corn prices become more variable.[2] In addition, the greater variability may provide more precise estimates of the separate supply inducing effects of corn and hog prices.

This note has two objectives: to determine the supply response of U.S. pork producers to changing hog and feed prices over time and to determine if the hog-corn price ratio is an adequate predictor of hog supply when the prices of both hogs and feed are volatile. A polynomial distributed lag model of quarterly U.S. hog supply response is estimated for two different time periods, 1960–69 and 1970–75. For each time period, two equations are estimated, one using the hog-corn price ratio as an explanatory variable (equation (1)) and a second using hog and feed prices as separate explanatory variables (equation (3)).

Table 1. Coefficients of Variation for Hog Price, Feed Price, and the Hog-Corn Price Ratio

	Coefficient of Variation	
Variable	1960–69	1970–75
Hog price	0.19	0.35
Feed price	0.09	0.39
Hog-corn price ratio	0.17	0.27

The general form of the estimated equations are

$$(1)\quad QS_t = \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + \alpha_4 D_4 + \alpha_5 T + \sum_{i=0}^{13} \beta(i)(PH/PC)_{t-i} + \epsilon_{1t},$$

where

$$(2)\qquad \beta(i) = \gamma_1 + \gamma_2(i) + \gamma_3(i)^2,$$

and

$$(3)\quad QS_t = \phi_1 D_1 + \phi_2 D_2 + \phi_3 D_3 + \phi_4 D_4 + \phi_5 T + \sum_{i=0}^{13} \delta(i) PH_{t-i} + \sum_{i=1}^{13} \theta(i) PF_{t-i} + \epsilon_{2t},$$

where

$$(4)\qquad \delta(i) = \lambda_1 + \lambda_2(i) + \lambda_3(i^2)$$

and

$$(5)\qquad \theta(i) = \mu_1 + \mu_2(i) + \mu_3(i^2),$$

and QS is commercial pork production (million pounds), PH is the average price of barrows and gilts at seven markets (dollars per hundred weight), PC is the average price received by farmers for corn (dollars per bushel), PF is 0.88 times the price of corn (dollars per ton), plus 0.12 times the price of 44% protein soybean meal at Decatur (dollars per ton), T is a time trend, and D_1, D_2, D_3, and D_4 are seasonal zero-one variables.[3]

Karl Meilke is an assistant professor in the School of Agricultural Economics and Extension Education, University of Guelph, Canada.

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[1] According to the *Livestock and Meat Situation* (USDA), corn accounts for approximately 51% and feed, 73% of the costs, excluding the feeder pig, of a Corn Belt hog-feeding operation. Several experiments were conducted to see if a hog-feed price ratio would predict better than a hog-corn price ratio, but in general there was little difference between the two variables. Nevertheless, when the two variables are separated, feed costs are used instead of the price of corn, accounting for the cost of soybean meal in pork production. No attempt was made to include nonfeed costs in the analysis.

[2] A reviewer has pointed out, and correctly so, that at current corn prices corn is not only an input into the pork production process but also a substitute for pork production. This is another reason why the hog-corn price ratio is less useful as a predictor now than previously.

[3] The Statistical Reporting Service considers the prices received by farmers and the prices paid by farmers to be the same.

Table 2. Estimated Hog Supply Response Equations, 1960–69

Time Period	Equation (1a)		Equation (3a)			
	PH/PC Coefficient	*t*-Value	*PH* Coefficient	*t*-Value	*PF* Coefficient	*t*-Value
t	−0.0522	−3.51	−0.0660	−2.79	0.0699	1.24
$t-1$	−0.0243	−2.08	−0.0370	−1.89	0.0290	0.73
$t-2$	−0.0001	−0.01	−0.0116	−0.70	−0.0059	−0.22
$t-3$	0.0205	2.39	0.0100	0.69	−0.0348	−1.77
$t-4$	0.0374	4.49	0.0279	2.13	−0.0577	−3.11
$t-5$	0.0505	5.99	0.0420	3.41	−0.0747	−3.57
$t-6$	0.0600	7.00	0.0524	4.43	−0.0856	−3.61
$t-7$	0.0658	7.70	0.0590	5.12	−0.0905	−3.52
$t-8$	0.0680	8.14	0.0620	5.42	−0.0895	−3.30
$t-9$	0.0664	8.19	0.0612	5.22	−0.0824	−2.86
$t-10$	0.0611	7.50	0.0567	4.45	−0.0694	−2.15
$t-11$	0.0522	5.84	0.0484	3.28	−0.0503	−1.28
$t-12$	0.0396	3.66	0.0364	2.03	−0.0253	−0.51
$t-13$	0.0233	1.69	0.0206	0.93	0.0057	0.09
Other variables						
Time	0.2320	6.64	0.3562	5.1446		
D_1	6.0751	25.14	8.1045	11.3261		
D_2	6.0000	24.82	8.0291	11.1671		
D_3	5.9462	24.54	7.9763	11.0689		
D_4	6.1275	25.21	8.1604	11.3570		
Mean lag		9.32		10.67		8.50
Sum of lagged coefficients		0.47		0.36		−0.56
R^2		0.91		0.92		
Durbin-Watson		1.59		1.73		
Observations		40		40		
Degrees of freedom		31		28		

Equations (2), (4) and (5) indicate that the weights assigned to past prices are represented by second-degree polynomial adjustment equations with a lag length of thirteen quarters. All but zero-one variables are converted to logarithms so the coefficients are elasticity estimates. The degree of the polynomial and the length of the lag were chosen following the procedure outlined by Meilke. Readers unfamiliar with polynomial distributed lags are referred to Chen, Courtney, and Schmitz; Kmenta, pp. 492–95; and Meilke.

The supply response functions contain the current price, so supply is determined simultaneously with demand. The equations are estimated using ordinary least squares for the reasons stated by Heien (p. 312). The results of estimating equations (1) and (3) for 1960–69 are given in table 2 and identified as equations (1a) and (3a). Both equations explain more than 90% of the variation in hog supply over the estimation period. This finding supports the argument that the hog-corn price ratio provides a good explanation of hog supply when the price of corn is relatively constant. The long-run elasticities from equation (3a) show that hog supply is more responsive to a 1% change in feed prices than in hog prices, given their respective elasticities of −0.56 and 0.36.[4]

Table 3 contains the parameter estimates for equations (1) and (3) in 1970–75. Contrary to the earlier time period, equation (1b) explains only 67% of the variation in hog supply compared with 98% by equation (3b). In addition, most of the coefficient estimates in equation (1b) have small *t*-ratios, while in equation (3b) they are much larger. The high degree of serial correlation in equation (1b) is also a good indication of misspecification, especially given that equation (3b) eliminates the serial correlation.[5]

In comparing equation (3) between the two time periods, three factors seem worthy of mention. First, the response of hog supply to changes in the price of hogs and feed is more rapid in the later time period with estimated mean lags of 7.22 and 5.78, respectively, compared with 10.67 and 8.50 in the earlier time period. Second, the elasticities of supply response with respect to both hog and feed prices are over three times as large in 1970–75 compared with 1960–69. Finally, the long-run feed price elasticity (−2.04) in 1970–75 tends to be slightly larger than the hog price elasticity (1.65) just as in the earlier time period.[6]

[4] Long-run elasticity is the sum of the regression coefficients on the price parameters.

[5] Serial correlation can of course be eliminated from equation (1b) using standard econometric techniques, but when serial correlation is due to misspecification it is surely better to correct for it by removing the specification error.

[6] All four of the equations estimated provide some empirical

Table 3. Estimated Hog Supply Response Equations, 1970–75

Time Period	Equation (1b)		Equation (3b)			
	PH/PC Coefficient	*t*-Value	*PH* Coefficient	*t*-Value	*PF* Coefficient	*t*-Value
t	−0.0372	−0.66	−0.0508	−2.34	−0.0941	−2.14
$t-1$	−0.0166	−0.29	0.0165	0.76	−0.1310	−4.21
$t-2$	0.0010	0.01	0.0734	3.10	−0.1606	−5.81
$t-3$	0.0154	0.24	0.1200	4.48	−0.1830	−5.83
$t-4$	0.0267	0.40	0.1563	5.18	−0.1982	−5.37
$t-5$	0.0350	0.50	0.1823	5.45	−0.2062	−5.00
$t-6$	0.0401	0.55	0.1979	5.43	−0.2069	−4.79
$t-7$	0.0422	0.55	0.2032	5.19	−0.2005	−4.70
$t-8$	0.0412	0.52	0.1981	4.76	−0.1868	−4.75
$t-9$	0.0370	0.46	0.1827	4.16	−0.1659	−4.90
$t-10$	0.0298	0.36	0.1570	3.40	−0.1378	−5.01
$t-11$	0.0195	0.23	0.1210	2.49	−0.1024	−4.19
$t-12$	0.0061	0.07	0.0747	1.45	−0.0599	−1.94
$t-13$	−0.0103	−0.11	0.0180	0.33	−0.0101	−0.22
Other variables						
Time	−0.7244	−3.10	2.0769	7.89		
D_1	9.7089	2.91	4.4657	6.33		
D_2	9.7033	2.92	4.4789	6.34		
D_3	9.6199	2.89	4.4273	6.28		
D_4	9.7581	2.93	4.5844	6.51		
Mean lag		8.54		7.22		5.78
Sum of lagged coefficients		0.23		1.65		−2.04
R^2		0.67		0.98		
Durbin-Watson		0.32		2.17		
Observations		24		24		
Degrees of freedom		15		12		

Although equation (3b) fits the historical time series better than equation (1b), this does not guarantee equations (3a) and (3b) will give better predictions than equations (1a) and (1b). To test this hypothesis, two prediction interval tests were conducted. The first reported in table 4 compares the performance of equations (1a) and (3a) in predicting hog supply from 1970(1) through 1976(2). The results indicate equation (3a) gave a mean absolute percentage error of 4% compared with 12% for equation (1a).[7] Similarly, the maximum single quarter error was 12% with equation (3a) and 32% with equation (1a).

The second prediction interval test consisted of using equations (1b) and (3b) to predict hog supply from 1976(1) through 1977(1) (table 5). Actual supplies are known only for the first two quarters. Consequently, the supplies reported for the last three quarters are the U.S. Department of Agriculture forecasts. USDA hog price forecasts plus futures market grain prices were utilized in predicting hog supply the last three quarters. The maximum difference between the USDA forecasts and the forecasts using equation (3b) is 5% in 1976(4) compared with an 18% differential in 1977(1) using equation (1b).

In conclusion, the above analysis supports the hypothesis that the hog-corn price ratio may provide a good explanation of hog supply when corn prices are constant but not when they are fluctuating. Consequently, forecasters and market analysts should consider the independent impacts of changing hog and feed prices on hog supply and not limit themselves to considering only the hog-corn price ratio.

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Table 4. Results of Using Equations (1a) and (3a) to Predict Hog Supply from 1970(1) through 1976(2)

	Equation (1a)	Equation (3a)
Root-mean-square error	395.00	161.80
Mean absolute error	281.70	130.80
Mean absolute percentage error	0.12	0.04
Maximum quarterly percentage error	0.32	0.12
R^2 (actual on predicted)	0.25	0.80
Number of time periods	22	22

support for Meyers and Havlicek's argument that short-run supply response may be negative.

[7] The relatively good forecasts using equation (3a) over the 1970–76(2) time period are quite surprising, given the statistically significant structural change between the two time periods.

Table 5. Results of Using Equations (1b) and (3b) to Predict Hog Supply from 1976(1) through 1977(1)

Time Period	Actual Supply (Million Lbs.)	Estimated Supply			
		Equation (1b) (Million Lbs.)	Percentage of Error	Equation (3b) (Million Lbs.)	Percentage of Error
1976(1)	2,895	2,749	−0.05	2,771	−0.04
1976(2)	2,782	2,712	−0.03	2,871	0.03
1976(3)	2,900[a]	2,520	−0.13	2,839	−0.02
1976(4)	3,300[a]	2,945	−0.11	3,461	−0.05
1977(1)	3,400[a]	2,797	−0.18	3,460	−0.01

[a] USDA.

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The Storage of Potatoes and the Maine Potatoes Futures Market

Benjamin Sexauer

The relationship between the storage of potatoes and the carrying charges reflected on the futures market for Maine potatoes gives rise to a situation in which the observed facts do not seem to agree with the accepted theory. The theory regarding intertemporal price relationships based on the work of Brennan, Telser, and Working establishes that the difference between the current price and the expected price of a storable commodity must be equal to the marginal cost of storage minus the convenience yield. The relationship between the amount of a commodity held in storage and the equality of the marginal cost of storage with the temporal price spread gives rise to a supply of storage curve. As estimated by Brennan, Telser, and Working, this supply of storage curve slopes upward to the right. More storage will be supplied at a high return per unit and less storage at a low return per unit stored.

The carrying charges reflected on the Maine potatoes futures market seemingly contradict the theory of the price of storage in two respects. First, the spreads between futures, which establish a return to storage, sometimes appear to greatly exceed any typically plausible cost of storage. On 1 March 1976, the March future for Maine potatoes sold for $8.35 per hundredweight, whereas the May future was selling for $12.63 per hundredweight. The return to storing potatoes for two months was $4.28 per hundredweight. Second, the relationship between the level of potato stocks and the carrying charge appears to be the opposite of that previously estimated for commodities with continuous inventories. For potatoes, the seasonal pattern associates large stocks with a narrow carrying charge and small stocks with a wide carrying charge. The level of potato inventories and the spread on the futures market produce a relationship that slopes downward to the right.

The fall potato crop accounts for over 75% of annual U.S. production and in recent years has been about 84% of the total. Fall crop potatoes are stored for consumption over a seven- or eight-month period. However, potatoes cannot be effectively stored for a whole year, since they are semiperishable. Potatoes, therefore, give rise to a discontinuous inventory situation. The task of intertemporal allocation is more difficult for a discontinuous inventory commodity. Potato prices must be established during the storage season with the objective of exhausting the supply of potatoes in storage coincidently with the availability of spring and early summer potatoes (Gray). Potato storage is conducted not by merchandising or storage specialists but primarily by growers. The primary requirements of a potato storage facility are adequate insulation, ventilation, and heating and the means to enter and remove the tubers efficiently.

Benjamin Sexauer is an assistant professor in the Department of Agricultural and Applied Economics, University of Minnesota.

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The Supply of Storage Relationship

The basic supply of storage relationship is $(P_t^{t+1} - P_t) = f(S_t)$, where P_t is price in period t, P_t^{t+1} is, in period t, the price expected to exist in period $t + 1$, and S_t is the inventory of the commodity. The important characteristics of the conventional supply of storage curve are the wide, basically horizontal segment in the middle, the steep upward slope when storage capacity is reached, and the negative price of storage section, which exists because of a convenience yield derived from inventory holding (Working, p. 1259).

In a rigorous development of this theory, Brennan conceived of a demand for storage and a supply of storage curve, which achieve equilibrium when the net marginal cost of storage equals the expected change in price. With a futures market, the expected price change is the relevant spread. The supply of storage curve is identified in a statistical sense because it remains basically stable, while the demand for storage curve shifts between seasons and within a season (Brennan, p. 57). The supply curves, estimated for a number of commodities, closely approximate the shape of the idealized supply of storage function. However, these supply of storage functions were estimated for highly storable, continuous inventory commodities such as the major grains. Brennan did examine the storage relationship for cheese, butter, and shell eggs, but these products, although perishable, are continually, not seasonally, produced.

In figure 1, the level of Maine potato stocks has been plotted with the relevant monthly carrying charge or return to storage reflected on the Maine potato futures market.[1] The monthly spread is be-

[1] The stock reports of the U.S. Department of Agriculture are defined as total stocks held by growers, local dealers, and

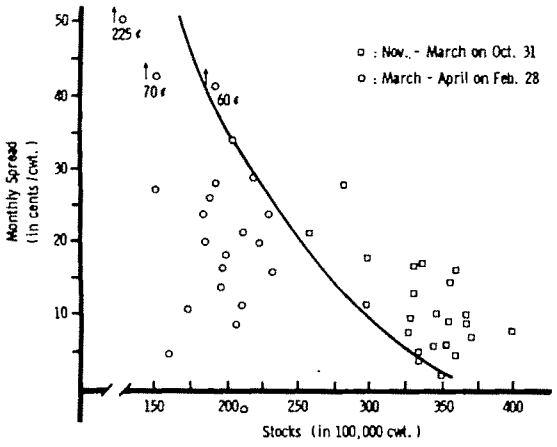


Figure 1. The relationship between the spread on the futures market and the level of potato stocks

tween the near future and the next future contract divided by the number of intervening months. In figure 1, the 1 March stock figures are aligned with the March to April spread on the last trading day in February for crop years 1954–74 (twenty-one observations), and the November stock levels with the November to March spread on the last trading day in October for 1952–74 (twenty-three observations).[2]

High stock levels in figure 1 are associated with a low carrying charge and low stocks with a high carrying charge, the reverse of the normal price of storage relationship. Also, there is no inverse charge; the carrying charge is always positive with one exception. The strong seasonal pattern is explained in the next section. Regression analysis of the data presented in figure 1 using ordinary least squares and an inverse functional form yields the following results:[3]

$$(1)\quad (P_t^{t+1} - P_t)/h = \underset{(3.04)}{-41.76} + \underset{(4.81)}{15{,}458}(1/S_t),$$

$$R^2 = 0.36,$$

where $(P_t^{t+1} - P_t)/h$ is the monthly carrying charge, the spread divided by the number of months h until the delivery month, and S_t is stocks of Maine fall crop potatoes. When equation (1) is plotted on figure 1, the problem is clearly revealed. The slope of equation (1) is negative, the opposite of the normal upward sloping supply of storage curve. In addition, the relationship between the monthly carrying charge and stocks is not a strong one. However, stocks are an important variable as reflected by the t-statistic.

The Costs of Potato Storage

The explanation for this pattern can be found in the influence that the potato's biological characteristics and its storage situation have on the costs of storage. The price of storage for potatoes is not primarily a function of the level of stocks, as Working's price of storage theory postulates. Potato storage is significantly more complex than storing grains. Potatoes are a tuber, a rather delicate living organism, which respires, loses weight, sprouts, and is subject to diseases and rotting. Because of the potato's perishability, the costs of storage are influenced by the length of the storage period, the price level, and the storage characteristics of the tubers.

Figure 2 quantifies as accurately as possible the costs of storing potatoes over the course of the storage season. The horizontal axis represents a temporal not a quantity measure. Figure 2 is based partially on cost estimates derived by Sparks. Although his studies apply to Russet Burbank potatoes in Idaho, the orders of magnitude, if not the exact values, should still be fairly applicable to the storage situation in Maine. The average fixed cost curve covers the investment costs of the storage facility including interest, taxes, insurance, and depreciation (Sparks, pp. 90–91).

The average basic costs curve includes the fixed costs, the costs of operation and maintenance, handling, and antisprout material, plus the costs associated with weight loss. Based on Sparks' figures and those from other studies, during a storage of six months a weight loss of some 5.61% to 6.65% can be

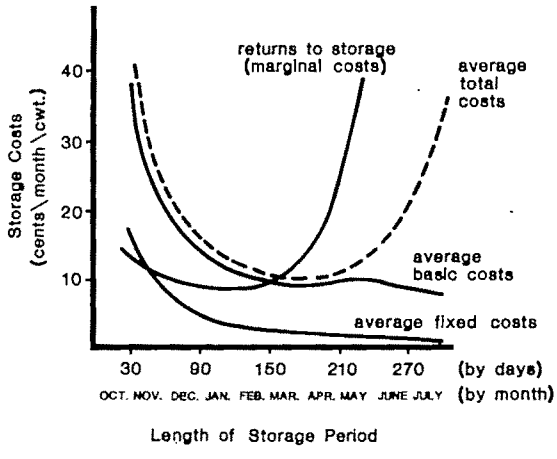


Figure 2. The pattern of storage costs over the storage season

processors and are equal to production minus disappearance (USDA 1952–69 annual, 1956, 1961, 1967, 1972; Pelsue and Kalaw).

[2] The stock reports for the first of the month are not issued until several days later. By using the spread on the last trading day of the preceding month, the assumption is made that the market accurately predicts the stock report before its issuance. Since a stock report is not issued on 1 November, this figure was computed based on the production figure, 1 December stocks, and the relation of total shipments through the end of October and through the end of November.

[3] The t-statistics are given in parentheses.

expected (Smith, p. 351; Sparks and Summers, p. 14). In addition, the monthly rate of weight loss is highest at the beginning and toward the end of the storage season. The cost is obtained by multiplying the percentage losses by the value of the potatoes. A price of $3.00 per hundredweight was assumed for figure 2. Even counting the cost of weight loss, average basic costs are a decreasing function of the length of the storage.

However, the tabulation of costs summarized in the average basic costs curve is incomplete. Potatoes undergo quality deterioration other than simple weight loss. The cost due to grade defects and quality change are also dependent on the price level and the length of storage. The average total cost curve adds the costs associated with quality change at a $3.00 per hundredweight price level to the average basic costs. This curve is drawn as a dashed line to indicate its hypothetical nature, but its measurement is based on a careful appraisal of potato storage. This distinction was made between a basic costs curve and a total costs curve due to the accuracy of the underlying cost estimates of the former and the less reliable inferences about some of the deterioration cost components of the latter.

The average total cost curve lies only slightly above the basic costs curve during the first part of the storage season when losses to quality change are low. However, deterioration losses are not a simple linear function of the length of the storage. Toward the end of the storage season, quality change losses begin to increase sharply as the tubers break dormancy and the outside temperature begins to rise and fluctuate. The percentage of monthly shipments of Maine tablestock potatoes with no sprouting has averaged over 99% through January for crop years 1966–73. The figure becomes 95% for February, 92% for March, 85% for April, 81% for May, and only 62% for June (Johnston and Pelsue, p. 27). Because of the potato tuber's ultimate perishability, storage losses would reach 100% at some point in the summer. The average total cost curve in figure 2 assumes that quality change losses would reach 100% sometime in July.

In addition, since potato storage is primarily by the grower, joint production considerations tend to increase the upward slope of the average total cost curve in the late spring. The potato producer-storer is engaged in two businesses, production and storage. Planting usually begins in Maine from 10 May to 15 May. The bulk of the Maine potato production is by small growers who simply do not have the capacity to be planting and moving potatoes out of storage at the same time. Planting must be given priority. Those growers that do store into May will probably be the larger outfits. They will require two crews, one for planting and one for potato handling. Therefore, the costs may be higher.

If all the relevant factors are taken into account, monthly potato storage costs have a U-shaped pattern over the storage season reflected in the average total cost curve in figure 2. The average total storage cost curve would shift upward for high priced potatoes and downward for low priced potatoes. The curve would also be affected by the storability of the crop. Although there is no simple physical measurement of this factor, tubers at harvest do vary from year to year in how well they will store. Weather conditions in the fall such as excessive cold or moisture and certain diseases produce tubers that have poor storage properties. For example, a frost in 1975 and heavy rains in 1972 prior to harvest gave rise to unusually severe storage problems.

Finally, the returns to storage curve in figure 2 describes the normal pattern of the carrying charge reflected on the futures market over the storage season. The return to storage has averaged 10.67¢ per month for November–March, 9.42¢ per month for January–March, and 32.81¢ per month for March–April for the years covered by this study. The carrying charge is normally somewhat lower on 31 December than on 31 October and rises sharply by 28 February. The return to storage curve would, in fact, approximately coincide with the temporal marginal cost curve if it were drawn in figure 2. As a general pattern, the carrying charges reflected on the futures market are equal to the cost of holding a unit of potatoes one more unit of time. However, the cost of storage and hence the return to storage are a function of the period in the storage season, the price level, and the storability of the crop, which shift the cost curves. The spread observed on 1 March 1976 could, therefore, accurately reflect the marginal cost of storing potatoes because of the very high price of $8.35 per hundredweight and the low storability of the 1975 crop due to frost damage.

The Carrying Charge Relationship for Potatoes

Previous analyses have assumed a stable supply of storage curve that was identified by the shifting demand for storage curve. However, for a seasonally produced, semiperishable commodity, the supply function is also shifting significantly over time. The storage cost per unit of inventory and the supply of storage curve shift as a function of the price level, the length of storage, and the storability of the crop. The supply of storage function for potatoes is not statistically identifiable in the normal single equation approach, which Brennan, Telser, and Working utilized. Therefore, the observed negative relationship between the carrying charge and the stock level should not be interpreted as a downward sloping supply of storage curve. A significant identification problem gives rise to the observed downward sloping carrying charge-stocks relationship for potatoes. The situation requires the simultaneous estimation of both the demand and supply schedule.

The demand for storage derives from the demand for consumption of the commodity. The change in price between the next period and the current period

$(P_{t+1} - P_t)$ is determined by consumption in the two periods. Consumption in a period is equal to the stocks carried into the period plus production minus stocks carried out of the period. In the demand for storage schedule, the price difference $(P_{t+1} - P_t)$ was specified by Brennan as a function of current stocks (S_t), stocks next period (S_{t+1}), and last period (S_{t-1}), current production (X_t), and production next period (X_{t+1}) (Brennan, pp. 51–52; Telser, pp. 234–35). This relationship is an *ex post* one, since P_{t+1}, S_{t+1}, and X_{t+1} are not known until next period. However, what is of interest is the perspective on the demand for storage in the current period. Therefore, this function should really be specified as an anticipated demand for storage with the difference between expected price and the current price $(P_t^{t+1} - P_t)$ being a function of the above factors, except that expected stocks (S_t^{t+1}) replaces S_{t+1} and expected production (X_t^{t+1}) replaces X_{t+1}. This demand curve should have a negative slope with respect to S_t.

Based on the storage characteristics of potatoes, the supply of storage function should be extended to include the price level, the length of the storage, and the storability of the crop as exogeneous variables. Observations on storability are not available, though. Estimation of the demand and supply schedule yield the following results:

$$(2)\quad (P_t^{t+1} - P_t)/h = \underset{}{15.17} - \underset{(0.30)}{18.94}S_t + \underset{(5.56)}{3.79}S_{t+1} + \underset{(5.47)}{15.92}S_{t-1} + \underset{(5.34)}{4.06}X_t - \underset{(5.57)}{3.34}X_{t+1} + \underset{(6.06)}{}$$

and

$$(3)\quad (P_t^{t+1} - P_t)/h = \underset{}{-23.07} - \underset{(0.48)}{0.0033}S_t + \underset{(0.26)}{0.0168}P_t + \underset{(6.79)}{7.56}D_t. \underset{(0.40)}{}$$

The dependent variable and S_t are specified as in equation (1), and D_t is a seasonal dummy variable: 0 for the November–March period and 1 for the March–April period; P_t is the price level of the near future; S_{t+1} is 1 March stocks for the November–March period and 1 April stocks for the March–April period; S_{t-1} is Maine fall production for the November–March period and 1 February stocks for the March–April period; X_t is winter crop production for the November–March period and early spring production for the March–April period, and X_{t+1} is early spring production for the November–March period and late spring production for the March–April period.[4] Both X_t and X_{t+1} apply to U.S. production, and S_{t+1} and X_{t+1} are substituted as proxies for S_t^{t+1} and X_t^{t+1}, since these expected levels are not observable.

Equations (2) and (3) were estimated by two-stage least squares to obtain consistent estimates of the coefficients, treating S_t as an endogenous variable. The functional form is linear. In equation (2), the demand for storage curve, the signs of the coefficients are as predicted by Brennan. However, in equation (3), the supply curve, neither the coefficient on stocks or the seasonal dummy variable are statistically significant.

There are two primary explanations for the disappointing estimates of the supply of storage function.[5] First is the necessary omission of storability as a variable. With storability omitted, the shifts in the supply curve are not accounted for adequately. Second, the supply function may not be statistically identified. Although the demand and supply schedules in their conceptual specification are both identified, the demand equation may not contain an adequate number of sufficiently exogenous variables to allow for the estimation of the supply function. In fact, variables considered exogenous in both equations such as S_{t+1}, S_{t-1}, and P_t may actually be endogenous to a fuller conceptualization of the system; hence, the demand function may also not be truly identified.

Conclusions

For the commodities previously studied, the cost of storage was primarily a function of the inventory level, and the observed carrying charge-stocks relationship was the supply of storage schedule. The demand function could not be statistically identified under those circumstances, though. For a discontinuous inventory, semiperishable commodity like potatoes, the price level, the length of storage, and the storability of the crop influence the cost of storage. Since both the demand and supply schedule are shifting, the observed downward sloping carrying charge-stocks relationship identifies neither schedule. In this analysis, the demand for storage function for potatoes has been estimated, but the supply schedule could not. For potatoes, the shifts in the supply schedule are substantial enough to trace out the demand schedule. Further work is suggested in estimating more precisely and completely the costs of storage and the supply of storage function as part of a more complete system. In addition, a means of measuring and the collection of data on the storability factor are needed.

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[4] An 1 April stock figure is only available since 1972. April stocks were estimated by subtracting March shipments from the 1 March stocks minus a 10% correction factor. The 10% correction factor was determined on the basis of the three years for which April stock data are available.

[5] In addition, a multicollinearity problem exists in equation (3), since the correlation between S_t and D_t, the seasonal dummy, is − 0.93. The November–March and March–April periods were, therefore, analyzed separately. However, this approach did not improve the estimates.

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Simulation of Agricultural Policy Formation as a Teaching Approach

Fred C. White

Policy formation can best be described as problem solving. Policies are formulated so that they appeal to a sufficient number of involved parties to accept the policy as an improvement over the present situation (Bauer). Understanding the environment and operation of this political process helps students formulate critical judgments concerning important economic policy issues. Because this process is so complex, it warrants special attention by educators. Agricultural policy instruction, in particular, has an opportunity to make economic abstractions meaningful and to get students involved in the learning process by analyzing relevant policy issues. Students can actively participate in a policy formulation learning process through role-playing simulation in which they represent people involved in real-world situations and make decisions based on available information. Such simulation helps students understand the policy-making process and the relationship between policy making and its results. This paper describes role playing simulation in agricultural policy classes.

Simulation and Gaming

One way to increase a student's ability to apply economic theory in a policy situation is to cast him in the role of economist and policy maker. In simulation, students participate in a decision-making experience within a controlled environment. The complexities of a real-world process are simplified, and certain representative features can be easily understood and readily manipulated (Taylor). By directly involving the student, he understands because of his own experience, observations, and analysis. The student is able to move from abstraction to reality after interpreting his behavior and analyzing the results (Joseph).

Simulation benefits the student in several ways. Students are exposed to a variety of viewpoints and a range of outcomes related to particular situations (Taylor). This process helps students understand the perspectives of individuals whose viewpoints differ substantially from their own. They can act on more decisions than in real life, and the results of the decisions are immediately revealed. With the results known, decisions can be evaluated through individual review or group discussion.

For almost a decade, agricultural economists have been interested in using simulation to teach university students. During this period, instructional simulation has been applied to several areas (Kendrick). One of the most popular applications has been in the field of commodity futures trading. Exercises in trading on futures markets were computerized to introduce greater market realism and to provide timely feedback on market activity (Eiler and Goodrich). Students have also used computerized tools to solve simulated farm management problems (see Boehlje, Eidman, and Walker; Curtis). Simulation games have been widely used to help students understand aggregate behavior of the economy (see Attiyeh, Nelson and Doeksen). These games also show students how public policies affect the economy. All of these procedures have one factor in common: they measure the impact of a particular decision. However, simulation procedures have not been widely used in economics to explore the decision-making process—an important part of policy formation.

Applying Simulation

Policy formation simulation was used as a theme for agricultural policy classes. The instructor could choose to pick up with simulation at any time during the course depending on the topic under consideration. The extent to which simulation was used at any one time ranged from simple group discussions to more elaborate simulation games. Simulation was used during approximately 15% of the total class time. To be most effective, simulation should be used after students have been introduced to factors and institutions affecting agricultural policy and the application of economic analyses to evaluate alternative governmental programs. Students are given information on policy formation simulation and assigned roles as senators or aides on the Agriculture and Forestry Committee of the Senate. Each participant represents a certain state and is asked to become familiar with the state he represents. The main goal of each participant is to exploit the situation to his advantage.

Through simulation the committee must make decisions on several agricultural policy issues. Con-

Fred C. White is an associate professor of agricultural economics, University of Georgia.

trasting viewpoints are often presented, and it is the committee's responsibility to reconcile these viewpoints and to develop a consensus statement on the issue. Group discussion, which helps the class to reach its decision, can show how well the students have grasped relevant economic principles.

Two types of games have been used as an integral part of simulation. The policy formation game indicates the problem-solving process by which agricultural policies are created. The second game is the policy simulator, which measures the economic impact of program alternatives. These two games are described in detail.

Policy Formation Game

The class, acting as the Agriculture and Forestry Committee of the Senate, attempts to put together a farm bill generally acceptable to a majority of the senators. Students consider any combination of the major farm commodities in developing the farm bill. The objective of this exercise is to include commodities from enough regions to get adequate regional support for the general farm legislation but without including so many commodities as to lose urban support. The committee's final bill is entered in a computer program to estimate how the actual Senate would vote on the proposed legislation. Results from this computerized analysis indicate which senators would be opposed to the bill and which would support it. Such an analysis of Senate votes gives the students more information on how to design commodity programs.

This simulation game is based on an analysis of Senate votes on 1975 farm legislation designed to increase target prices and support prices for several farm commodities. A discriminant analysis procedure classifies senators as probably belonging to one of three groups: opposing a particular piece of farm legislation, supporting it, or not voting. Social, political, and economic variables that are hypothesized to affect voting behavior are used to delineate the groups. It was assumed that the discriminant functions estimated for votes on a particular commodity (tobacco in this case) could be applied to legislation that would increase support prices or target prices for other commodities by using the percentage of farm income derived from the particular commodity under consideration. The next step involved linking Senate votes for specific commodities together to form a general farm bill concerning several commodities. If a senator voted for legislation to increase support prices for any commodity, he was assumed to support the total farm bill. Other senators would be categorized as opposing the farm bill or not voting, depending upon their stands on legislation for individual commodities.

Added realism in the simulation game was achieved by allowing for different levels of target prices and support prices for each commodity. As long as the farm programs were modest in scope, i.e., having low government costs and little impact on food prices, legislators would be more attentive to agricultural interests. However, as government costs and food prices increased, more opposition to the farm bill would develop. This formulation provided a systematic approach for predicting how senators would vote on farm bills that raised support prices and target prices for various combinations of commodities.

This approach to policy formation provides a classroom atmosphere in which students are free to interact and to express their opinions. The students analyze the simulation exercise in terms of the problem considered, alternative choices, factors influencing a choice, and conflicting roles.

Policy Simulator

Policy models and simulation in current policy research can sometimes be adopted for educational purposes. With a policy simulator game, students must use a problem-solving approach with the following steps: quantify policy goals, formulate theories concerning instruments and targets, and test hypotheses by drawing conclusions from empirical evidence. These steps let students make policy decisions on their own and evaluate the impact of these decisions through the aid of computers.

The particular game that has been used with policy formation simulation deals with the peanut program. Peanuts are one of the few commodities that remain under strict government control. Consequently, the administration and many legislators are interested in modifying or eliminating the program.

This policy simulator is based on a market model of the peanut sector that can be used to explore the implications of changing this program (see Fleming and White). How alternative programs affect production, government and consumer costs, and net farm income is a major consideration. Use of the model was first demonstrated in class by analyzing the peanut sector for 1976–80 under the present price support program. Results show that, if the present peanut program is continued, government costs will increase substantially.

The simulated Agriculture and Forestry Committee of the Senate then explored alternative programs for peanuts. Alternatives considered include marketing quotas, a two-price plan, and a free market policy. Students must consider the impact of these programs on government costs, consumer costs, peanut production, and net farm income.

This approach helps students become aware that policy makers must choose among alternatives. The best choice among these alternatives will depend on two things: how the economic system functions and society's preferences. Forcing students to make a choice from among the alternatives ensures that they understand the effect of the program and have weighed the relative importance of such factors as government costs and farm income.

Evaluation of Simulation as a Teaching Tool

Simulation is an exciting technique to use. The teacher can incorporate debates, field trips, guest lecturers, individual reports, and small group discussions to help make simulation more effective and enjoyable for student learning. It offers flexibility and variety and provides a realistic picture of the way policies are developed, analyzed, and initiated. Simulation can give students the opportunity to think, analyze, and make decisions effectively.

Because students are actively involved in this learning process, they are highly interested and enthusiastic. This teaching method develops students' decision-making abilities because they are asked to give views and feelings on different policy issues. Students must be able to analyze policy situations effectively in order to give intelligent opinions.

A follow-up survey at the end of the course provided an opportunity for students to evaluate the procedure. Student comments highlighted several areas they thought were important. With simulation, students exercised their analyzing capacities to deal with real-world problems and issues, which helped them be better informed in agricultural policy. Simulation provided insights into potential conflicts surrounding policy issues and the mechanisms whereby decisions could be reached. Most importantly, the procedure gave students a better understanding of the intricacies of policy formation.

Using simulation in the classroom required the teacher and student to collect detailed data, do systematic analysis, and organize important relationships. Students improved their understanding of agricultural policy issues and the process that resolves them. Students realized that the roles they played affected their perceptions and evaluations of the situation. Thus, they had a greater appreciation of the policy-making process.

Simulation does, however, have disadvantages. The students have a greater burden than with lectures because they must prepare for the reports, debates, and discussions. When simulation is properly used in conjunction with other techniques, much class time must be devoted to simulation in order for the students to gain the greatest learning benefit. Evaluating student performance can be a problem. Although tests are used to measure student learning, it is difficult to measure everything that the students learn using simulation. The teacher can require that written reports be handed in to evaluate the student's work. Also, through observation, the teacher can subjectively evaluate student performance.

Public policy students must understand the nature of public decisions and how those decisions are made. They must also learn to analyze policy issues and make critical judgments concerning those issues. These educational objectives can best be achieved by actively involving students in the policy-making process. Simulation allows students to participate in this process by casting them in the role of policy makers. Furthermore, students reacted enthusiastically to simulation; they enjoyed the competition in the games and the variety of ways that the issues were introduced and discussed. This approach can effectively be used to supplement more traditional lecture techniques.

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Technological Change and Relative Factor Shares in Indian Agriculture: An Empirical Analysis: Comment

Henry Y. Wan, Jr.

In a recent study, Srivastava and Heady (S-H) maintain that technical progress has raised the elasticity of factor substitution in Indian agriculture. They observe that the high-yield varieties require more labor inputs in shorter planting and harvest seasons. Hence, the peak-season wage has risen, but overall employment has not improved. The end result is a reduced labor share in agricultural income.

The S-H estimation procedure is justified only under certain neoclassical assumptions. However, if these assumptions hold, then the S-H formulation in production function estimation is not compatible with the S-H explanation of changing labor shares in assessing the seasonality of labor demand, and, considering the nature of existing technical progress in Indian agriculture, either the S-H sample data are unrepresentative of the Indian agriculture, or the S-H results neither reflect the underlying production technology nor explain the causal determination of the labor share. In what follows, the S-H model formulation and the estimation procedure are reviewed before considering the nature of technical progress in the Indian agriculture.

The Method of Estimation

The S-H study selects two periods: the a priori pretechnological progress epoch of 1954–57 and the a priori posttechnological progress epoch of 1966–70. For each epoch, a constant elasticity of substitution (CES) production function is fitted to the cross-farm microsample data from two Indian districts, Ferozpur and Muzzaffernager. Using cost accounting records, the ratio of labor time (in man-days) to fixed capital (in rupee value) is regressed log-linearly to the ratio of rental rate to average wage rate as well as to dummy variables.

The methodology adopted by these authors has been questioned by various economists in recent years. Weitzman, for example, prefers to estimate the CES production function directly from input-output data. To him, the use of factor prices calls for the making of tenuous assumptions such as individual rationality (in cost minimization) and market perfection. Nadiri and Rosen believe that adjustment costs should be considered in studying the producers' behavior. Aigner, Amemiya, and Poirier and Schmidt consider that the interproducer differences in efficiency should be accounted for.

If, for a particular sample study, the interfarm differences in inertia, inefficiency, or rationality constitute an important yet omitted explanatory variable, then there can be little assurance that findings from the sample are representative for the national economy. Whether the S-H study is biased on this score and what is the nature of the bias, if any, can only be determined by an independent empirical study, a task beyond my present scope. What I shall show is that the S-H study may encounter difficulties in any case.

To begin with, in view of the opinions of Weitzman and others, the procedure used in the S-H study must be justified by the following neoclassical postulates: both individual rationality and market perfection are workable hypotheses; neither adjustment costs nor differences in efficiency or information are of much consequence. Yet in the framework of these assumptions made explicit for the S-H study, several conceptual and logical issues arise.

The Model Formulation

In their statistical work, the authors use both annual labor time and average wage rate in a two-input production function. This approach is justifiable only if the seasonality of labor demand is of little importance. In their policy analysis, the authors recommend rural work programs to guarantee the landless a minimum subsistence income in the face of the technical change. They also comment on the changing seasonality of labor demand. This changing seasonality is not just a matter of descriptive accuracy but also a point of analytical relevance. If the high-yielding varieties do not affect employment levels in all seasons, the observed increase of the average wage rate must imply an increase in the wage bill. *Ceteris paribus*, this in turn increases the

Henry Y. Wan, Jr., is a professor of economics, Cornell University.

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absolute level of the income of the landless, if not their relative shares as well. Therefore, technical progress per se calls for no safeguard to preserve the subsistence of the landless. Rural work programs may be laudable in their own right. They are strictly a *non sequitur* in the present context. Consequently, any need for rural work programs (in response to technical progress) reflects the changing seasonal pattern of labor demand. But to explain the latter, no production theory can succeed if there is only a single labor input. From this viewpoint, a seasonal disaggregation of the labor input not only will bypass the well-known difficulties in aggregation (see Fisher) but also will meet the policy need. The satisfaction of the latter is, after all, the raison d'etre of the S-H exercise.

In short, on the issue of seasonality, the reader is forced to choose between the S-H model formulation and the S-H policy analysis. For the sake of subsequent discussion, I take the S-H two-input production function for granted.

The Nature of Technical Progress

Conceptually speaking, the adoption of any new technology can have one of two outcomes: (*a*) the technical progress is superseding: the old technology is completely displaced, or (*b*) the technical progress is coexistential: the old technology survives beside the new. Nowhere in Asia has the "green revolution" displaced the traditional technology in toto (see, e.g., Dalrymple). In other words, technical progress is coexistential and not superseding. Within the neoclassical framework indispensable for the S-H estimation procedure, this means that two two-input production functions are in use side by side—one for the new technology and one for the old. This may be analyzed in figure 1 below via the Lerner diagram (see, e.g., Findlay and Grubert).

In figure 1, the two broken-line unit "output" isoquants characterize the old and new technologies. (By output is meant value added in the S-H context.) They are representable as $F_i(K_i, L_i, u_i) = 1$, for $i = 0$ (old) and n (new), where $F_i(\cdot)$, K_i, L_i, and u_i stand for the production function, the capital input, the labor input, and the random parameter for technology i, respectively.

Given the pair of values u_0 and u_n, the two technology-specific unit-output isoquants are fixed. Together they determine uniquely first, the common tangent line $P_0 P_m P_n$, whose slope is the coexistential factor price ratio, at which both the old and the new technologies allow the attainment of the same minimum unit cost for the output (both technologies may be adopted by cost-minimizing producers if and only if the market factor price ratio coincides with the coexistential factor price ratio), and second, the least-cost rays OP_0 and OP_n going through origin O and the tangency point P_0 and P_n (between the technology-specific unit-output isoquants $Q_0 P_0$ and $P_n Q_n$ and the line $P_0 P_m P_n$), whose slopes are the least-cost factor proportions under the coexistential factor price ratio. Between OP_0 and OP_n lies the coexistential cone. Both technologies must be adopted if and only if the equilibrium factor proportion ray for the agricultural sector lies in the interior of the $P_0 OP_n$ cone.

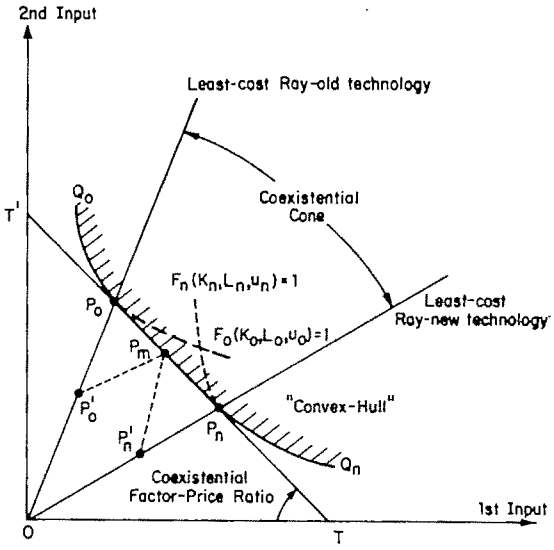


Figure 1. The Lerner diagram

The input-output proportions for a producer using only the old (new) technology are identifiable with the point $P_0(P_n)$. The overall input-output proportions for a producer using both technologies are identifiable with a point P_m between P_0 and P_n.[1] Consider the convex hull for the union of the two technology-specific unit output isoquants. The boundary of this convex hull, the solid locus $Q_0 P_0 P_m P_n Q_n$, is the sectoral unit-output isoquant in the posttechnological change epoch. It shows all the alternative minimum input combinations that can produce one unit of output.

In traditional view, technical progress brings about a new technology unit-output isoquant, which lies uniformly below and leftward of its counterpart under the old technology. For the posttechnological change epoch, the former is the sectoral isoquant. No sample point in this epoch represents any firm using the old technology. While such a view is consistent with both "biased" and "neutral" techni-

[1] A farm with an input vector $\overrightarrow{OP_m}$ has too much (little) first input to use the old (new) technology only. It will allocate inputs, as represented by $\overrightarrow{OP'_0}$ to produce grain with the old technology and allocate the rest, as represented by $\overrightarrow{OP'_n} = \overrightarrow{OP_m} - \overrightarrow{OP'_0}$, to produce grain with the new technology. $\overrightarrow{OP'_0}(\overrightarrow{OP'_n})$ lies along the least cost ray of the old (new) technology. Output from the old (new) technology amounts to $\overrightarrow{OP'_0}/\overrightarrow{OP_0}(\overrightarrow{OP'_n}/\overrightarrow{OP_n})$. Total output can be shown to be one. While there is no technology that is x% old and (100 − x)% new, one can always produce x% of its output with the old technology and (100 − x)% with the new, x being any number between 0 and 100. The resulting convex hull is generated by two isoquants only. This is not an envelope, which can assume a similar form only when a continuum of isoquants are present.

cal progress however defined, it is easily shown that all the Harrod-neutral, Hicks-neutral, and Solow-neutral technical progresses must conform to this traditional view. Atkinson and Stiglitz first pointed out that real life technical progress tends to be localized in nature. Both Jones and Bhagwati amplified this view; under some factor-price ratios, the old technology may remain to be economical. In terms of the Lerner diagram, the two unit-output isoquants cross as in figure 1. Atkinson and Stiglitz paid no attention to the case where both technologies may be simultaneously in use—the case followed through here.[2] Due to the assumptions of constant returns as well as the absence of production externality between the two technologies,[3] the convex-hull construction exists in figure 1. Both technologies will be simultaneously in use if and only if the equilibrium factor supplies to the agricultural sector correspond to an input vector (like $\overrightarrow{OP_m}$) inside the coexistential cone

Under coexistential technical progress, a variation of the sectoral input vector inside the coexistential cone cannot affect the market (i.e., coexistential) factor price ratio or the least-cost factor proportions in either technology. Likewise, the change of the sectoral factor proportions cannot be deduced from the variation of the factor-price ratio. For the sector as a whole, the elasticity of substitution is formally ∞ (due to the uniqueness of the coexistential factor price ratio).

The traditional causal decomposition formula for changing relative shares (S-H equation (4), which follows Brown) is inapplicable to the coexistential technical progress. The only thing to be said is that the ratio of relative shares is the product of the factor-price ratio and the sectoral factor proportions. The former is technologically determined, while the latter is determined by all factors both in and outside the agricultural sector in a general equilibrium fashion. In figure 1, the relative shares ratio may be anywhere between $\overline{TP_n}/\overline{P_nT'}$ to $\overline{TP_0}/\overline{P_0T'}$.

What can be said of the S-H estimation depends upon whether all farms in their sample adopted new technology only (their paper did not provide this information). If the answer is yes, then S-H has estimated the new technology unit-output isoquant. Since the old technology coexists with new in India, their sample is not representative of the economy-wide situation. Whatever they have deduced on factor shares relates only to the ratio of $\overline{TP_n}/\overline{P_nT'}$ and not to the relative shares in Indian agriculture, which relates to a ratio between $\overline{TP_n}/\overline{P_nT'}$ and $\overline{TP_0}/\overline{P_0T'}$ in figure 1. If the answer is no, then their sample is a "mixed bag," some sample points identifiable with P_n, others with P_0, and still others with points like P_m. Their findings do not pertain to the new technology since extraneous observations exist in the sample. Nor does their estimate of the elasticity of substitution portray well the sectoral isoquant, since their sample points correspond to the entire $P_0P_mP_n$ segment. By prior information, it is apparent that within the relevant range such an elasticity is ∞. This is not merely the quantitative question: how accurately do their findings approximate reality? One might maintain that all fitted production functions are approximations anyway. But the culmination of the S-H study is their causal decomposition of the variation in the factor shares. For that task, they rely upon a particular formula—a formula that breaks down with infinite elasticity of substitution (as stated in point 2 above).

Summing up, it appears that for future studies both the seasonality of labor demand and the coexistence of both old and new technologies should be explicitly taken account of on the conceptual as well as empirical planes.

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[2] As shown in Wan, coexistential technical progress is far from being a knife-edge curiosum.

[3] Mutual benefits between apiculture and floriculture exemplifies production externality between different operations. No comparable externality seems to exist between food grain production using the two technologies.

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Technological Change and Relative Factor Shares in Indian Agriculture: An Empirical Analysis: Reply

Uma K. Srivastava and Earl O. Heady

Wan provides some interesting and useful extensions and interpretations of the Lerner diagram. It is a useful analysis and provides certain evaluations of our methods and suggestions of policy alternatives.

To incorporate seasonality of labor demand, he suggests a seasonal disaggregation of labor inputs. This disaggregation would certainly be useful if the data were available. However, the data available five years ago were only in terms of total man-days and the wage bill for the crop production period as a whole. Hence, we could not use the suggested approach. However, the average wage bill was still considered relevant since the custom hiring facilities for tractors and other mechanical devices were scarce, and the farmer's decision to substitute capital for labor was considered to be rather independent of the ratio of average wage rates over the crop period to the average price of capital.

New technology in agriculture (high-yielding varieties, mechanical aids, etc.) is never adopted simultaneously by all farmers. In India also the "green revolution" was coexistential in nature in the sense that old technology was used beside the new. Numerous studies have shown that coexistence prevails because of resource constraints (credit facilities in particular) and risk aversion on the part of the continued users of old technology and not because of particular economic advantage of these technologies (Rao; Srivastava, Crown, and Heady). In these circumstances, it does not seem justifiable to use Lerner's diagram even for a theoretical argument on the elasticity of substitution and relative factor shares as restraints. If we examine events over the four years since our paper was written, high-yielding varieties have progressively covered most of the area in the wheat belt where the green revolution took place. It was the small and marginal farmers who were constrained by resources in switching to new technology. Special measures to bring them into the fold of the green revolution have gradually relieved the constraints.

The post-green revolution data used related to high-yielding varieties, while the prerevolution data referred only to local varieties. Despite coexistential technological progress, the available data should reflect changes taking place in the relative factor shares. With the progressive increase in the coverage of high-yielding varieties, one naturally expects changes to be further accentuated. An alternative to our analysis would have been merely "to wait and see." Under the country's vastness and the diversity of soil, climate, human, and other physical resources, our study at best was intended to be regarded as an indicator of changes taking place in the regions experiencing the green revolution. The problem of the poor in regions lacking such technological change was outside our study objectives.

Wan states, "If the high-yielding varieties do not affect employment levels in all seasons, the observed increase of the average wage rate must imply an increase in the wage bill. *Ceteris paribus*, this in turn increases the absolute level of income of the landless, if not their relative shares as well. Therefore, technical progress per se calls for no safeguard to preserve the subsistence level of the landless." The stated objective of our study was to examine the changes in the relative factor shares because these have an important bearing on the prevalent disparities in income between haves and have-nots in Indian agriculture. Any assessment of technology from the point of view of society necessarily needs to be concerned with the undesirable side effects of technological change (Hetman).

Our study admitted the possibility of increased absolute shares to both labor and capital. We observed, however, that the green revolution had brought about a decline in the relative share of labor. This finding itself suggests a possible undesirable consequence of the green revolution. Further, this finding along with additional information (not generated in our study) that the number of people below the poverty line has grown despite the increase in total production and that the bulk of the rural poor are the landless agricultural laborers and small farmers were used to emphasize the need for policy measures designed to augment the incomes of rural poor. The recommendation of a rural works program was mentioned as one such measure but was not intended to be taken as the only policy measure. Subsequently, several studies have supported our findings regarding the decline in the relative shares of labor and a widening of disparities between haves and have-nots in Indian agriculture and the develop-

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Uma K. Srivastava is with the Institute of Management, Ahmedabad, India, and Earl O. Heady is a Curtiss Distinguished Professor of agriculture, Iowa State University.

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ing countries (Rao; International Bank for Reconstruction and Development). The root cause has been an unequal distribution of the basic resources—land and finances (Srivastava, Crown, and Heady). Several corrective measures have since been taken in developing countries (International Bank for Reconstruction and Development). In India, more stringent land ceilings, a redistribution of lands to the landless, opening of rural banks specifically for small farmers, landless laborers, and small artisans (Government of India), debt relief, and special development programs (Srivastava and George) are examples.

[*Received August 1976.*]

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Interaction of Energy and Food Prices in Less Developed Countries: Comment on a Reply

Emery N. Castle

In a reply to a comment by Konandreas and Green in the August 1976 issue of this *Journal*, Timmer refers to my discussion of his original paper. Both Timmer and I were ambiguous on a particular point. In his reply, Timmer says, "after consideration of possible empirical applications, I now think that the only purpose of the model was to remind us that we all live in an interdependent world where everything affects everything else. It is an elementary point but one that is frequently forgotten. Attempts to quantify it are not likely to be very rewarding" (p. 595). In my original comment on his article I said, "Timmer has surely reached the maximum physical product on his production function in the use of this model. Further extensions may well result in negative marginal returns unless the assumptions of the model are relaxed or unless the model, as formulated, is buttressed by greater treatment of the empirical magnitudes involved" (p. 246). I did not intend to suggest that an attempted empirical development of Timmer's model would necessarily be fruitful, but I believe empirical investigations, utilizing a different theoretical framework, of some of the variables involved would be useful in the interpretation of the model results presented in the original paper. I believe this has been demonstrated by Konandreas and Green. Surely empirical investigation may be of value in interpreting the results of deductive analysis alone.

Emery N. Castle is a senior fellow and vice-president at Resources for the Future.

This point is minor in the context of Timmer's original paper, which I regard in a favorable way. As a methodological issue, the point is not minor, and my original comment should have been more precise. The only empirical work of value does not have to involve the direct application of a model such as Timmer's. Conversely, the value of such a model does not depend on direct empirical application. But this does not mean that we can best interpret the results of such models by ignoring what we have learned about the world by other means, nor does it mean that such models cannot be made more valuable by empirical work that utilizes a different frame of reference.

[*Received August 1976.*]

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Books Reviewed

Mellor, John W. *The New Economics of Growth: A Strategy for India and the Developing World.* Ithaca, N.Y.: Cornell University Press, 1976, xv + 335 pp., $11.50.

This ambitious book is bent on convincing the national policy makers of India that there is an employment-oriented high path to national development that will lead to adequate food, employment, and growth. The author views agricultural production and labor mobilization not only as a means to human sustenance and fulfillment but also as instruments in restructuring and accelerating industrial growth. The work is aimed primarily at the refined minds that are, or advise, India's leadership. It also appeals to professional specialists committed to the study of India's contemporary economic scene. At another level, it seeks to communicate with specialists interested in the development of other low-income, densely populated agrarian areas.

The book is carefully organized in parallel with the four major elements that the author insists must be changed if an employment-oriented strategy is to succeed. The first three substantive chapters examine the agricultural sector and India's experience with the green revolution in view of the impacts technical advances can have on the improvement of life for the rural poor. This is in keeping with the first change condition that an employment-oriented strategy "must give priority to increasing agricultural production through investment in new technology" (p. 13).

The next three chapters deal with industrial growth, the industrial sector's uneven capital structure and swings in productivity, and the expansion of demand for industrial goods through rapid growth in the rural sector. This parallels the author's second change condition that an employment-oriented strategy "must reduce the capital requirements per employee in the industrial sector and tap new sources of capital through decentralization of production" (p. 13). The relatively small but highly influential aspects of foreign trade and foreign assistance are taken up in the next two chapters. These support the author's third change condition that "to expedite the decrease in capital intensity, the growth rate of both exports and imports must increase," with an emphasis on capital-intensive imports and labor-intensive exports (p. 13).

After a single-chapter interlude that treats the need for public services in health, nutrition, family planning, education, and the like, the author draws the public service theme into his final chapter dealing with the political basis of national planning and the choice of growth strategy. This emphasis parallels his fourth change condition that, in an employment-oriented strategy, "planning and administrative procedures and institutions must also be decentralized and emphasis switched from regulatory to facilitatory procedures" (p. 13).

The author's method is evidently systematic. There is no reason for a reader to get lost at any point in the book. Not only do the chapters flow from the four necessary conditions of the strategy being advocated but the chapters themselves have parallel internal structure. Each chapter is launched with a summary statement of the substance of its argument. It generally flows from that point into an examination of relevant data, which is usually followed by a speculative essay or commentary.

The ideas in the book are not new, although if India were to adopt the basic employment-oriented strategy, that would be new. The retrospective portions of the various chapters are perhaps the most attractive sections. Not only are they instructive regarding the events of recent decades in India but they introduce the reader to the work of a number of Indian social scientists who are not widely known in the United States. The speculative discussions in the chapters lack comparable strength and are, in places, admittedly theoretical, tending to be equivocal about the future. The book's argument is more an indictment of the failures of the capital-intensity strategies that were implemented during the second and third plan periods (1956–66) than it is a well-argued brief on behalf of a wholesale switch to employment orientation in economic policy. The unhappy part about the work's appearance at this time is that no westerner—even one of the author's standing—is likely to have much influence in India today. The country is presently in no position to accommodate any bold steps in favor of genuine decentralization. Also, the country does not have the resources to put into developing and promoting relevant agricultural technology on a scale similar to the relative levels of investment in agricultural research and extension being made by the industrialized nations. This impedes any changes in the patterns of trade and foreign assistance.

I would estimate that this book will be widely read because of the importance of the subject and the author's excellent credentials. However, it is unlikely to become the guidebook for economic planners that the author intends it to be.

Nicolaas Luykx
East-West Center

Sjo, John. *Economics for Agriculturalists: A Beginning Text in Agricultural Economics* and *Teachers Aid*. Columbus, Ohio: Grid, 1976, 232 pp. and 128 pp., prices unknown.

From an agriculturalist's point of view, Sjo has written a basic text in economics for agriculturalists. Many traditional topics in agricultural economics are included with the more fundamental material found in contemporary microeconomic textbooks. Sjo's book is about one-third the size of the latter, but what has been gained in cost reduction and printing efficiency may be an illusion, as beginning students in underdivision classes ponder the underlying relationships and theory that the text material is based upon.

The book is one of contrasts. The introduction to each chapter and reading lists are excellent. The chapters covering descriptive material on the changing structure of agriculture, the role of agriculture in the development process, and emerging problems in agriculture are generally good, although sometimes lacking in depth. The major weaknesses of the book are in its theoretical presentation and its theory-application linkups. For instance, in early chapters Sjo stresses the point that, while traditional agricultural economics was primarily concerned with production problems, increasing emphasis is being placed on market-oriented problems. However, as the text develops, most topics that would be included in an intermediate production economics text are presented, while demand analysis and market structure are given very cursory treatments. Co-ops and marketing orders are briefly mentioned, but no analysis is attempted to show how they improve a farmer's profit position. Also, detailed flow diagrams of market channels are presented, but any theoretical development of how products move through these channels (such as the concept of derived demand) is missing.

Brevity of presentation takes its heaviest toll in the theoretical sections. The consumer demand discussion is confusing as it jumps from ideas of individual demands, to market demands, back to indifference curves, to income and substitution effects, to income elasticities, to price elasticities, and to demand facing a firm in pure competition in about ten short pages. Will the student become confused and not grasp the more fundamental concepts? The topics included in the production section may be too ambitious for an introductory text. Unfortunately, an understanding of production theory is made more difficult because of several incorrect examples and illustrations. For example: (*a*) on page 66, the author says the beginning of stage 2 is where average product is maximum; however, the example shows stage 2 beginning at a different point; (*b*) in showing the impact of price changes on output, the stages of production are ignored altogether; (*c*) in moving from production functions to cost curves, the cost curves are drawn incorrectly, since cost is plotted with units of input on the horizontal axis; (*d*) in the figure on page 82, the profit area is incorrectly illustrated; and (*e*) the author defines average product to be an efficiency measure of productivity but describes regions of increasing constant and decreasing productivity using the marginal physical product function.

In the market structure portion of the book, it is implied that forces of supply and demand only operate to determine prices in perfect competition. It is difficult to visualize the firm-market relationships in this section, and students may be persuaded that there is a greater degree of head-to-head competition as one moves from perfect competition to monopolistic and oligopolistic competition. In the discussion of monopoly the author incorrectly defines the marginal cost curve of a monopolist to be his supply curve, and marginal revenue is presented in such a manner that there is no evident relationship between it and the demand curve. Finally, while the author describes oligopoly to be the predominant form of market structure in the United States, his discussion of oligopoly pricing is very limited.

Brevity of presentation in other chapters may also lead to misconceptions on the part of students such as: profit is related to producing products with the largest consumer demand; the more preferred a product, the greater is its income elasticity; if per unit costs are decreasing, a firm should automatically use more inputs to increase its profit; advances in technology increase the profits of producers; a business aware of diseconomies will cut back its size to increase profits; and the slope of a supply curve is a measure of price responsiveness of producers.

The well-done *Teacher's Aid* summarizes the purpose of each chapter, identifies important terms, and lists study questions, problems, quizzes, and test questions and answers. After reading the *Teacher's Aid*, a contemporary advertisement came to mind: "leave the driving to us." Some may be very tempted to "leave their thinking to Sjo."

Economics for Agriculturalists introduces the world of economics in an agricultural setting and presents a good summary of the changing structure of American agriculture and its importance in our economy. However, we feel that considerable reworking is needed in the theory sections if the book is to be used in an introductory course in agricultural economics.

A. Robert Koch
Richard W. Stammer
Rutgers University

Sorenson, Vernon L. *International Trade Policy: Agriculture and Development*. International Business and Economic Studies, Graduate School of Business Administration, Michigan State University, 1975, xix + 290 pp., $6.00 paper.

This book was written for classroom use and treats international agricultural trade in a global context, including issues of concern to both advanced and less developed countries. The focus is strongly on

agricultural trade policy rather than on trade theory or trade research. The book is written at a level appropriate for an international agricultural trade course for upperclassmen and beginning graduate students. Teachers of agricultural policy and agricultural development will also find individual chapters appropriate as supplementary readings for their courses.

The beginning two chapters survey international trade policy and trends in trade flows in a historical context. Emerging trade problems of both advanced and less developed countries are identified.

Chapter 3 presents basic trade theory concepts relevant for agricultural trade analysis, while chapter 4 contrasts arguments for free trade versus trade restriction and discusses the interrelations between domestic agricultural policy and trade policy. Partial equilibrium tools to analyze the economic and welfare effects of protection are presented. These two chapters comprise the theoretical core of the book. While the level may be adequate for beginning graduate students, more advanced students would require additional supplementary readings in trade theory.

The next two chapters contain a useful description and analysis of domestic agricultural policy and its relation to trade in advanced countries, particularly the European Community and the United States. Multilateral trade negotiations under the General Agreement on Tariffs and Trade are also discussed. These two chapters should prove useful to students of both agricultural policy and international trade.

Agricultural trade issues of the less developed countries are treated in chapters 7 through 10. Chapter 7 reviews the relationship between trade and development and discusses the objectives of the U.N. Conference on Trade and Development. The next chapter describes several proposals for international commodity agreements and compensatory financing schemes, followed by a review of the barriers to the developing countries' exports and a discussion of the roles of trade liberalization and customs unions. This section ends with chapter 10 on trade sector planning. These four chapters would make useful supplementary readings for a course in agricultural development.

The final chapter attempts to pull together the various topics treated in the book and to put current trade policy issues in perspective.

The principal strengths of the book lie in its descriptions and analyses of domestic agricultural and trade policies in both developed and developing countries and in its discussion of the issues related to the recent calls for a new international economic order by the developing countries. The basic elements of international trade theory relevant for understanding agricultural trade are reviewed in chapters 3 and 4. However, I am concerned with an apparent antitheory bias, which runs through the book. This is unfortunate, especially for students at the formative stage who have not yet acquired an appreciation for the role of theory in empirical economic research. International trade theory offers a rich source of hypotheses for empirical trade studies, which is underplayed by Sorenson.

Sorenson also downplays the importance of general equilibrium analysis, arguing for a partial equilibrium framework for empirical work (chap. 3). However, general equilibrium feedback effects of a policy change may be important, as is demonstrated in chapter 10 in a discussion of trade sector planning. Where these effects are important, general equilibrium effects need to be taken into account in empirical studies.

In his treatment of trade policy issues, particularly those relating to the developing countries, Sorenson attempts to give a very balanced treatment in which all viewpoints are represented. However, in his attempt to be fair and unbiased, Sorenson has been somewhat uncritical in presenting arguments whose merits must be judged on other than economic criteria. In addition, he tends to overlook the impediments that the developing countries themselves have put in the way of their exports, such as exchange rate overvaluation and quantitative controls.

Two topics of current trade policy interest are not treated in the book. One concerns the effect of exchange rate changes on agricultural exports. When prices in several different countries are converted to a common currency for comparison, no indication is provided concerning what exchange rates were used (or whether they might be interpreted as equilibrium rates). The second issue that is not treated concerns the implications of monopsonistic importers, such as centrally planned economies, confronting a competitive export market.

It is no discredit to Sorenson that he has not solved all these problems. He has brought together in a well-organized and clearly written volume a wealth of information on international agricultural trade policy, which should serve as a textbook and useful reference for students and teachers of agricultural trade policy in both developed and developing countries.

Robert L. Thompson
Purdue University

Books Received

Arbuckle, Wendell S. *Ice Cream Service Handbook.* Westport, Conn.: AVI Publishing Co., 1976, 130 pp., price unknown.

Barnard, C. S., and J. S. Nix. *Farm Planning and Control.* New York: Cambridge University Press, 1973, viii + 549 pp., $12.95.

Berry, Albert, and Miguel Urrutia. *Income Distribution in Colombia.* New Haven, Conn.: Yale University Press, 1976, xvii + 281 pp., $15.00.

Breimyer, Harold F. *Economics of the Product Markets of Agriculture.* Ames: Iowa State University Press, 1976, x + 208 pp., $11.95.

Carvajal, M. J., and David T. Geithman. *Family Planning and Family Size Determination.* Gainesville: University of Florida Press, 1976, 96 pp., $5.00.

Damachi, Ukandi G., Guy Routh, and Abdel-Rahman E. Ali Taha. *Development Paths in Africa and China.* Boulder, Col.: Westview Press, 1976, xv + 251 pp., $24.75.

de Bruijne, G. A., J. Hardeman, and J. J. F. Heins, eds. *Perspecitief op Ontwikkeling? (Perspective on Development?).* Bussum, Holland: Uniebock, 1976, xvii + 276 pp., price unknown.

Deman, J. M., P. W. Voisey, V. F. Rasper, and D. W. Stanley. *Rheology and Texture in Food Quality.* Westport, Conn.: AVI Publishing Co., 1976, ix + 588 pp., price unknown.

Donald, Gordon. *Credit for Small Farmers in Developing Countries.* Boulder, Col.: Westview Press, 1976, xi + 286 pp., $20.00.

Douglas, Edna. *Economics of Marketing.* New York: Harper & Row, Publishers, 1975, viii + 728 pp., $25.00.

Enyedi, G. Y. *Rural Transformation in Hungary.* Budapest, Hungary: Adademiai Kiado, 1976, 116 pp., $7.00.

Faaland, Just, and J. R. Parkinson. *Bangladesh: The Test Case for Development.* Boulder, Col.: Westview Press, 1976, xi + 203 pp., $20.00.

Farrall, Arthur W. *Food Engineering Systems, vol. 1.* Westport, Conn.: AVI Publishing Co., 1976, x + 615 pp., $45.00. $20.00 paper.

Fuller, Anthony M., and Julius A. Mage. *Part-Time Farming: Problem or Resource in Rural Development.* Norwich, England: Geo Abstracts Ltd., 1976, vi + 291 pp., $12.00.

Hill, Lowell D. *World Soybean Research.* Danville, Ill.: Interstate Printers & Publishers, 1976, xvii + 1073 pp., price unknown.

International Legal Center. *Law and Public Enterprise in Asia.* New York: Praeger Publishers, 1976, xiii + 421 pp., $27.50.

Kalter, Robert J., and William A. Vogely. *Energy Supply and Government Policy.* Ithaca, N.Y.: Cornell University Press, 1976, 356 pp., $18.50, $5.95 paper.

Kehoe, Dalton, David Morley, Stuart B. Proudfoot, and Neal A. Roberts. *Public Land Ownership: Frameworks for Evaluation.* Lexington, Mass.: D.C. Heath and Co., 1976, xv + 211 pp., $17.00.

Morss, Elliott R., John K. Hatch, Donald R. Mickelwait, and Charles F. Sweet. *Strategies for Small Farmer Development.* Boulder, Col.: Westview Press, 1976, v + 444 pp., price unknown.

Mountney, George J. *Poultry Products Technology.* Westport, Conn.: AVI Publishing Co., 1976, ix + 369 pp., $19.00.

Orden, Gerald. *The United States Forest Service: A Historical Bibliography, 1876–1972.* Davis, Cal.: Agricultural History Center, 1976, vii + 439 pp., price unknown.

Roe, Daphne A. *Drug-Induced Nutritional Deficiencies.* Westport, Conn.: AVI Publishing Co., 1976, xi + 272 pp., price unknown.

Roumasset, James A. *Rice and Risk: Decision making among low-income farmers.* New York: American Elsevier Publishing Co., 1976, xxi + 251 pp., $34.75.

Saunders, Robert J., and Jeremy J. Warford. *Village Water Supply: Economics and Policy in the Developing World.* Baltimore, Md.: Johns Hopkins University Press, 1976, xii + 279 pp., $15.00, $6.00 paper.

Schertz, L. P., A. R. Stevenson, and A. M. Weisblat. *International Training in Agricultural Economic Development.* New York: Agricultural Development Council, 1976, viii + 118 pp., $5.00.

Stout, B. A. *Energy for Agriculture: A Computerized Information Retrieval System.* 4th ed. Agricultural Engineering Department, Michigan State University, Sept. 1976, 317 pp., $5.00.

Swierenga, Robert P. *Acres for Cents: Delinquent Tax Auctions in Frontier Iowa.* Westport, Conn.: Greenwood Press, 1976, xix + 262 pp., $14.95.

Thrall, R. M., E. Heady, T. Schad, A. K. Schwartz, and R. G. Thompson. *Economic Modeling for Water Policy Evaluation.* Amsterdam: North-Holland Publishing Co., 1976, xvii + 261 pp., $20.95.

Upton, Martin. *Agricultural Production Economics and Resource-Use.* New York: Oxford University Press, 1976, x + 357 pp., $23.00.

Winter, George R. *Protein Efficiency in Canada.* Montreal: Canadian Livestock Feed Board, 1975, ix + 330 pp., $5.50, $3.50 paper.

Announcements

Annual Meeting, 1977

The annual meeting of the American Agricultural Economics Association will be held jointly with the Western Agricultural Economics Association on 31 July–3 August at the Town and Country Hotel, San Diego, California. Overall responsibility for the program is shared jointly by Kenneth Farrell, president of the AAEA, and William Martin, president of the WAEA. John Redman, secretary-treasurer of the AAEA, is in charge of the arrangements. Correspondence concerning the 1977 meetings should be directed to the appropriate person. Information regarding the facilities, contributed papers program, etc., has been sent to all AAEA members. Further program information, along with registration and reservation forms, will be forthcoming in presidential letters and from the secretary-treasurer. Contributed papers information is repeated in this issue.

Symposium on Southern Agriculture

A symposium, "Southern Agriculture Since the Civil War," is to be held in Starkville, Mississippi, in June 1978. Joining in sponsoring the meeting are the Agricultural History Society, the U.S. Department of History, and Mississippi State University. Persons wishing to present papers at the symposium may correspond with Wayne D. Rasmussen, Agricultural History Group, Economic Research Service, U.S. Department of Agriculture, Washington, D.C. 20250, or with Roy V. Scott, Department of History, Mississippi State University, Mississippi State, Mississippi 39762.

Contributed Papers for the Annual Meeting

Contributed papers are invited for the 1977 AAEA meeting at San Diego. No subject matter restrictions are placed on contributed papers other than required relevance to the discipline of agricultural economics. In the past, session titles have included a wide range of subjects such as natural resources, firm growth, farm management, water, marketing, energy and the environment, international trade and development, and other topics of interest to agricultural economists. Papers submitted are considered for presentation and are titled after all papers are reviewed for relevance, quality, and potential contribution to knowledge. Availability of meeting rooms at the San Diego meetings will probably limit the total number of contributed papers to between sixty and seventy, in contrast to more than one hundred during the last several years. Because a more complete review is required, papers should be forwarded by first class mail and must be postmarked no later than midnight, 1 April 1977.

Each author is limited to one contributed paper for which he is the sole or senior author. Contributions by graduates and undergraduate students are solicited. The papers, including tables, footnotes, and references, should not exceed twelve double-spaced pages. Authors are urged to follow the *Journal* guidelines in preparing manuscripts for review. Each manuscript must be accompanied by a fifty-word abstract.

Presentation of contributed papers (as well as presentation and/or discussion of invited papers and invited addresses) at annual meeting is limited to AAEA members, except in special cases where the condition is waived by the president.

Copies of the abstract will be available at registration and in advance of the session as an aid to participants. Also, the abstract of each contributed paper that is accepted and presented in the sessions will be printed in the 1977 proceedings issue of the *Journal*. Authors are invited to submit their contributed papers to the *Journal* editor for consideration at a later date, subject to the normal review process.

Each manuscript for the contributed papers sessions must be accompanied by facts needed by session chairmen to introduce the authors to the audience. A minimum set of information includes name, title, institutional affiliation, advanced degrees, and a brief employment profile.

The following dates are important. By 1 April 1977 three copies of the manuscript, a fifty-word abstract, and a biographical sketch must be submitted, postmarked no later than midnight, to cochairmen Daniel D. Badger or Harry P. Mapp, Jr., Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma 74074. By 15 June 1977 authors are notified of the status of their papers. The AAEA meetings are held in San Diego, California, 31 July–3 August 1977.



Personnel

Agricultural Development Council

Appointment: William L. Collier, formerly with the Department of Agricultural and Resource Economics, University of Hawaii, is a council associate in Bogor, Indonesia.

University of Arizona

Appointment: Roger A. Selley, formerly with the Ford Foundation, is an assistant professor.
Resignation: John C. Day, former associate professor, is an agricultural economist, Technical Assistant Bureau, Agency for International Development, Washington, D.C.

University of Arkansas

Resignation: James A. Bogart, former research assistant, is a field representative, Federal Land Bank, Pine Bluff, Arkansas.

University of California, Berkeley

Appointments: Peter Berck, Ph.D. M.I.T., and **Michael Hanemann,** Ph.D. Harvard University, are resource economists.

University of California, Davis

Appointment: Rulon D. Pope, Ph.D. University of California, Berkeley, is an assistant professor.

University of Chicago

Appointment: G. S. Tolley is the coeditor of a new journal, *Resources and Energy*.
Honors: D. Gale Johnson, professor of economics and provost, is a member of the American Academy of Arts and Sciences; **Theodore W. Schultz,** professor emeritus, received the Elmhirst Medal from the International Agricultural Economists Association, July 1976, and is a trustee for the International Agricultural Development Service.

Clemson University

Resignation: Clayton Grant, visiting assistant professor, is a teacher in the Department of Business, Brenau College, Gainesville, Georgia.

NRED: National Economic Analysis Division of the Economic Research Service; SRS: Statistical Reporting Service.

Colorado State University

Leave: Robert A. Young is on a research assignment with the Department of Farm Management, Lincoln College, Canterbury, New Zealand.

University of Connecticut

Leave: Carlos Stern, associate professor, is on leave with the U.S. Geological Survey, Reston, Virginia.
Retirement: Arthur W. Dewey, former professor, has left after thirty years of service.
Honor: Stewart Johnson, professor emeritus, received the Distinguished Member Award from the Northeastern Agricultural Economics Council for 1976.

Cornell University

Appointment: William G. Lesher is acting assistant professor of land use policy, 1976–77.

University of Florida

Appointments: William D. Mulkey, formerly at Clemson University, **Thomas H. Spreen,** formerly at Purdue University, and **George B. Wall,** formerly at North Carolina State University, are assistant professors of food and resource economics.

University of Georgia

Appointment: Chung-Liang Huang, Ph.D. Virginia Polytechnic Institute and State University, is an assistant professor, Georgia Experiment Station.

Iowa State University

Appointment: Kenneth E. Stone is an assistant professor of economics.
Resignation: Gordon C. Rausser, former professor of economics, is a professor of economics, Harvard University.

Kansas State University

Appointments: Randy Baden, formerly with Garden City Junior College, is an area extension specialist-economics stationed in Garden City; **Bryan W. Schurle,** Ph.D. Ohio State University, is an assistant

professor of farm management-research and teaching.
Return: David W. Norman is back after acting as chairman, Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Nigeria, since 1965.
Resignation: J. J. Kropf, former extension economist, is with Livestock Business Advisory Services, Kansas City, Missouri.

Michigan State University

Appointment: Peter Matlon, Ph.D. Cornell University, is an assistant professor in the international programs area.
Resignations: William R. Bentley, former professor of resource economics and management, is the manager of Forestry Research, Crown Zellerbach Corporation, Camas, Washington; **William Crowley,** ERS, USDA, is entering private business.

University of Minnesota

Appointments: Duty D. Greene, M.E. North Carolina State University, is a research specialist in farm management and production economics research; **Andrea J. Lubov,** Ph.D. Washington State University, is a research associate in public services.
Honor: E. Fred Koller, professor emeritus, received the 1976 National Cooperative Month Education Award for his outstanding talents as a teacher and educator of sound cooperative concepts.

University of Missouri

Leave: Brice Ratchford is a visiting professor in extension economics-marketing and agricultural policy, Kansas State University.

University of Nebraska

Appointment: Dean Linsenmeyer, Ph.D. Michigan State University, is an assistant professor of agricultural marketing.

University of New Hampshire

Appointment: Bruce E. Lindsay is an assistant professor of regional economics, Institute of Natural and Environmental Resources.

Oklahoma State University

Appointment: Gregg L. Parvin, M.S. University of Arkansas, is an assistant in research.

Oregon State University

Appointment: Kenneth C. Gibbs, former associate professor, University of Florida, is with the School of Forestry.
Resignation: Timothy M. Hammonds, associate professor, is a research director, Super Market Institute.

Pennsylvania State University

Appointment: James G. Beierlein is an assistant professor of agricultural business management.

Prairie View A&M University

Resignation: M. A. Soliman, former associate professor, Department of Economics and Geography, is a professor of economics, Kuwait University, Kuwait.

Purdue University

Appointments: Martin T. Pond is the acting program director of community development; **James Pratt** is a research assistant; **Ram D. Singh** is a research specialist.
Return: Ramon B. Wilson, professor, is back from Washington, D.C.
Resignation: Joann C. Mullen is a teacher, Morton Memorial School, Knightstown, Indiana.
Honor: Robert C. Keen is vice-president of the International Board of Directors, Farm House Fraternity.

University of Rhode Island

Appointments: Nancy E. Bockstael and **Jon G. Sutinen,** Ph.D.'s University of Rhode Island, are assistant professors in resource economics.
Leave: John Gates is on sabbatical leave for one year with the Office of Extended Jurisdiction, National Marine Fisheries Service, Washington, D.C.

Southern Illinois University

Resignation: Gordon Langford, former associate professor, Department of Agricultural Industries, is in private industry, Denver, Colorado.

U.S. Department of Agriculture

Appointments in SRS: Donald W. Barrowman is the assistant director, Research Division, and a USDA clearance officer; **Richard P. Small** is the statistician in charge of the Florida State Statistical Office; **Carroll D. Spencer** is the statistician in charge of the Wisconsin State Statistical Office.

Utah State University

Appointment: Allen LeBaron is the codirector, Office of Sectorial Planning, Ministry of Agriculture, Bolivia, Utah State University Contract.
Return: Morris D. Whitaker is back after serving as codirector, Office of Sectoral Planning, Ministry of Agriculture, Bolivia.

Washington State University

Leaves: Desmond O'Rourke, associate professor, is on leave with the Economics and Social Research Institute, Dublin, Ireland, through Aug. 1977; **Norman K. Whittlesey,** professor, is on leave with Environmental Economics, NRED, ERS, USDA, Colorado State University, through Aug. 1977.

West Virginia University

Appointment: Virgil Whetzel, ERS, USDA, Colorado State University, is with the Division of Resource Management.

University of Wyoming

Appointment: James L. Stephenson, M.S. University of Wyoming, is a research associate.

Other Appointments

Paul K. Blakeley, Ph.D. Virginia Polytechnic Institute and State University, is an agricultural economist, Agricultural Canada, Ottawa.

Faustino Ccama, M.S. Virginia Polytechnic Institute and State University, is at the Universidad National Tecnica Del Altisplano, Puno, Peru.

Thomas J. Cusack, Ph.D. Oregon State University, is a research economist, Agricultural Institute, Dublin, Ireland.

Demitri Damianos, Ph.D. Virginia Polytechnic Institute and State University, is with the Research and Planning Division, Agricultural Bank of Greece.

Daniel Hartley, M.S. University of Wyoming, is with the Wyoming Department of Agriculture, Cheyenne.

John E. Schefter, Ph.D. Oregon State University, is with the U.S. Geological Survey, Reston, Virginia.

James R. Sinclair, M.S. University of Wyoming, is with Cargill, Inc., Minneapolis, Minnesota.

Cynthia Tinberg, Ph.D. Michigan State University, is an associate economist in regional economics, Midwest Research Institute.

Roberto Cristian Zegers-Prado, Ph.D. University of Minnesota, is at the Universidad Austral de Chile, Valdivia, Chile.

Obituary

Marshall D. Harris

Marshall D. Harris died of a heart attack 17 August 1976 in Shelbyville, Kentucky. He had retired from the Economic Research Service, U.S. Department of Agriculture, in 1973 and returned to his native state after thirty-nine years of federal service. In the last nineteen years of service he was affiliated with the Agricultural Law Center at the Law School, University of Iowa, which he was instrumental in helping to form.

Harris was born in Kentucky in 1903 and received his undergraduate education at the University of Kentucky, graduating in 1926. He did graduate work at Kentucky and Illinois and received his Ph.D. in 1942. In 1946, he received a study grant by the General Education Board to assume residency at Duke University while rewriting his doctoral thesis, which was later published by the Iowa State College Press in 1953 as *Origin of the Land Tenure System in the United States*.

Harris's federal service began in 1933 as a special investigator for the Farm Credit Administration, USDA. He subsequently worked for the Agricultural Adjustment Administration, USDA; Natural Resources Board, U.S. Department of the Interior; Resettlement Administration, Farm Security Administration, Bureau of Agricultural Economics, and the Economic Research Service.

During his career, Harris was closely involved with land tenure and agrarian reform and was a pioneer in interdisciplinary legal-economics research. Always a prolific writer, at one count he had well over 100 publications to his credit. In addition to *Origins*, he was involved in editing and producing numerous other books including *Family Farm Policy*, *Agrarian Reform and Moral Responsibility*, *Town and Country Churches and Family Farming*, and *Land Tenure Research Workshop* (all coedited with Joseph Ackerman). With Harold Halcrow, he edited *Modern Land Policy*, and with Ackerman and Clawson, *Land Economics Research*. He wrote a large number of Agricultural Law Center monographs and also prepared USDA extension material on Farm Leasing that is still being used today. His major research efforts at the time of his retirement was the locus of entrepreneurship in agriculture. He received the USDA's Superior Service Award in 1961.

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Articles

Market Price Effects of Technological Change on Income Distribution in Semisubsistence Agriculture

Yujiro Hayami and Robert W. Herdt

The impact of a technologically induced rightward shift in the supply function of a commodity grown and partly consumed by semisubsistence farmers is examined. In closed-economy, free market situations, the distribution of economic gains between consumers and producers depends on the proportional shift of the supply function, proportion of the commodity marketed, and elasticities of demand and supply for the commodity. Differences in adoption and marketable surplus between large and small farmers result in differential benefits, but over a range of parameter values, small farmers gain as much or more than large farmers when supply shifts faster than demand.

Key words: income distribution, subsistence agriculture, supply shifts, technological shifts.

Since the emergence of new cereal technology in Asia, the impact of technological change on income distribution has become a major concern. Attention has focused on a number of issues suggesting that technological advance may contribute to an increased concentration of income. The arguments cited usually include faster rates of adoption by "big" compared with "small" farmers or by owners compared with tenants, a labor-saving bias in the technology that reduces labor's share, nonadaptability of technological innovations to all geographic areas, a tendency for public services to be available to big farmers but not to small, and incentives for landlords or wealthy farmers to consolidate small holdings into larger units, thereby promoting a polarization of the rural population.[1]

While neither denying nor affirming these arguments (they appear to hold in some cases and not in others), the purpose of this paper is to examine a neglected impact of technological change on income distribution—the market price impact. The essence of the argument is as follows. Technical progress for a commodity implies a downward shift in the cost function and hence a rightward shift in the supply function, which with a downward sloping demand curve results in an increase in economic welfare through the consumption of a larger quantity at a lower cost.

Distribution of the gains in economic welfare between consumers and producers depends on the price elasticities of demand and supply for the commodity. In economies where farm producers sell almost all their output and farm product demand is price inelastic, consumers are the main beneficiaries of farm technological process, with farmers finding themselves trapped on a technological "treadmill." (For a classical treatment, see Cochrane.) However, when a major fraction of the commodity is consumed in the households of producers and not traded in the market place, some of the consumers' surplus from technical progress is internalized by those producers. Since they sell some fraction of their output, they are called semisubsistence producers.

If demand is price inelastic and prices are permitted to adjust to market forces, the de-

Yujiro Hayami is on the faculty of economics, Tokyo Metropolitan University, Japan, and Robert W. Herdt is an agricultural economist at the International Rice Research Institute, Los Baños, Philippines.

The authors acknowledge the assistance of Masao Kikuchi in the mathematical development of the model. The helpful criticisms of Vernon Ruttan, Robert Evenson, Jim Ryan, Reed Hertford, T. W. Schultz, and D. G. Johnson are acknowledged. Any remaining shortcomings in the paper are the responsibility of the authors.

[1] These arguments are mentioned by Wharton, Falcon, Johnston and Cownie, and Staub and Blase. More emotional exposition of some are provided by Frankel and by Griffen. Little empirical evidence is cited by any of the authors.

gree of consumers' surplus internalized by farm producers is inversely related to the proportion of output sold. If the commodity's price is fixed by government policies or determined by the international market, then the technological change may not result in any price change. In such a case, the distribution of benefit will accrue to producers in direct proportion to their sales.

In this paper, a model is developed that incorporates this special attribute of semisubsistence production into an analysis of the relation between technical change and income distribution in a closed economy, both among sectors and within sectors. The model is applied to data on rice economy of the Philippines to illustrate the potential influence of technological development in rice production technology.

The total income distribution effect of the introduction of technological advances will depend on the impact such an introduction has on the factor shares and on the ownership distribution of the factors as well as on its impact on market prices. While recognizing the importance of the former issues, in this paper we focus on the latter.

A Model of Income Distribution

Critical considerations in the analysis of the distribution of gains from technical progress in the production of a subsistence crop are: (*a*) the subsistence crop is produced by a mass of small producers so that its market can be approximated by perfect competition, (*b*) the subsistence crop is a "necessity" good characterized by a low price elasticity of demand, (*c*) a major portion of the subsistence crop output is consumed by the producers' households and a minor portion is sold in the market, and (*d*) the price for the crop is set by demand and supply in the domestic market.

Intersectoral Distribution

Figure 1 shows the demand and supply schedules of a subsistence crop in the market. The vertical line (D_HH) represents the demand curve of producers for home consumption. Considering the subsistence crop as a basic need, producers' households are assumed to consume a given quantity of their produce irrespective of prices and to sell the rest in the market. (In a later section, this assumption is modified by making consumption responsive to output.) The market demand for the product is represented by D_MD; the horizontal difference between D_MD and D_HH measures the quantity purchased by nonfarm households. The total demand for the crop is represented by D_HD_MD.

The supply schedules before and after a technical change occurs are S_0O and S_1O. Corresponding to the shift in the supply schedule, the market equilibrium point moves from A to B. Nonfarm consumers enjoy the

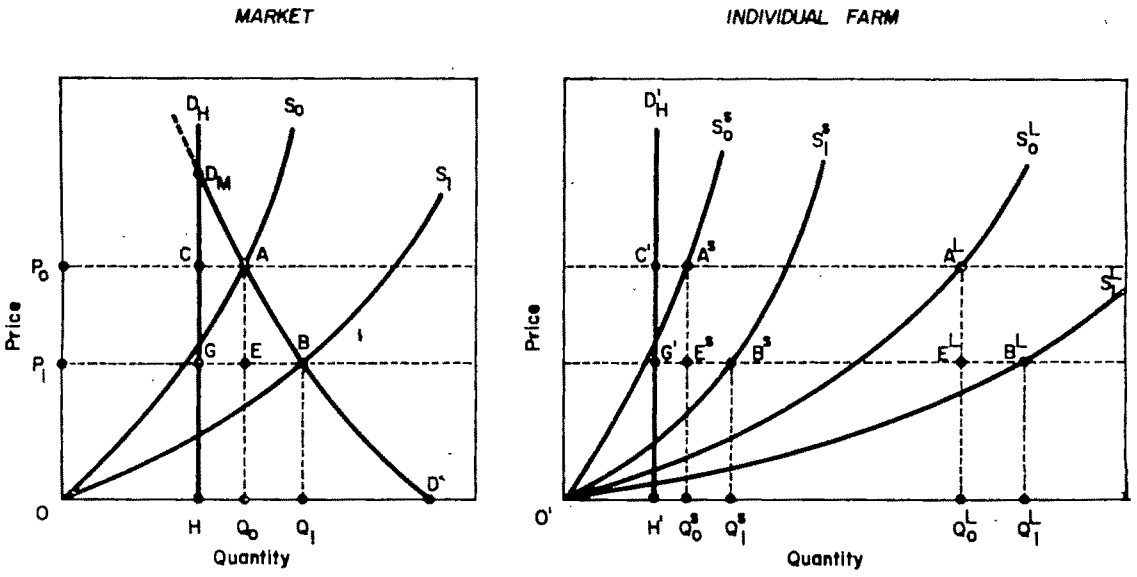


Figure 1. The impact of technological change in a subsistence crop

increased consumption (HQ_0 to HQ_1) at the reduced price (OP_0 to OP_1)—consumers' surplus increases by area $ACGB$. On the other hand, producers' cash revenue changes from area $ACHQ_0$ to area $BGHQ_1$, while producers' home consumption stays the same, OH. The cost of production changes from area AOQ_0 to BOQ_1.

Assuming that the real income value of home consumption of the product by producers is represented by the quantity consumed, income changes to producers are reflected in changes in their cash income.[2] Whether producers' cash income (revenue minus cost) is increased by the technical change depends on the demand and supply functions. However, clearly, the larger is the ratio of home consumption, the more likely it is that producers' incomes will increase. For example, if agriculture is completely commercialized and home consumption is zero (D_HH coincides with the vertical axis), the reduction in cash revenue is area AP_0P_1E − area BEQ_0Q_1, which is clearly much larger than area $ACGE$ − area BEQ_0Q_1, which is the case of subsistence agriculture. In either case the change in cost is measured by area AOQ_0 − area BOQ_1. On the other hand, the increase in consumers' surplus is clearly smaller in subsistence agriculture (area $ACGB$) than in commercialized agriculture (area AP_0P_1B).

Approximate the relevant range of the total demand schedule (D_HD_MD) by a typical constant elasticity demand function:

$$q = cp^{-\eta}, \tag{1}$$

where p and q are, respectively, the price and the quantity demanded of a subsistence crop; c includes income and other demand shifters; and η is the price elasticity of demand.

Assume a constant elasticity supply function as

$$q = bp^{\beta}, \tag{2}$$

where p and q are the price and the quantity supplied; b includes supply shifters except technical change; and β is the price elasticity of supply. Assuming a k% shift in the supply schedule due to technical progress, the new supply function (S_1O) can be expressed as

$$q = b(1 + k)p^{\beta}. \tag{3}$$

If the equilibrium price and quantity before the technical progress are denoted as p_0 (= OP_0) and q_0 (=OQ_0), respectively, those after the technical change, p_1 (= OP_1) and q_1 (= OQ_1), can be approximated as[3]

$$p_1 \cong p_0\left(1 - \frac{k}{\beta + \eta}\right) \tag{4}$$

and

$$q_1 \cong q_0\left(1 + \frac{\eta k}{\beta + \eta}\right), \tag{5}$$

provided that k is a relatively small percentage change.

Consumers' gain in terms of the increase in consumers' surplus is expressed as

$$\begin{aligned} \text{(6)}\quad \text{Area } ACGB &= \text{area } AP_0P_1B - \text{area } CP_0P_1G \\ &= \int_{p_1}^{p_0} cp^{-\eta}\,dp - q_0(1 - r)(p_0 - p_1) \\ &\cong p_0q_0\frac{kr}{\beta + \eta}, \end{aligned}$$

where r is the ratio of marketable surplus (total output minus home consumption) to total output, i.e., $r = HQ_0/OQ_0$. Equation (6) shows that consumers' gain from the technical progress is larger as r is larger or as the production of the crop is more commercialized.

Correspondingly, the cash revenue of producers will change by

$$\begin{aligned} \text{(7)}\quad &\text{area } BEQ_0Q_1 - \text{area } ACQE \\ &= p_1(q_1 - q_0) - q_0r(p_0 - p_1) \\ &\cong p_0q_0k\frac{(\eta - r)}{\beta + \eta}, \end{aligned}$$

which indicates that producers' cash revenue will increase if r is smaller than η. In other words, the less commercialized is the production, the larger is the gain in producers' cash revenue (or the smaller is the loss).

Meanwhile, the cost of production will change by

[2] One could carry through the analysis by including the consumers' surplus of farm producers as the measure of their welfare. Using that approach does not provide any fuller understanding because what producers gain as consumers from the technical change they lose as producers. Producers' consumers' surplus increases by the area CGP_1P_0, while their producers' surplus is reduced by the same amount. Because concern is focused on the changes induced by technological advance, the alternative analytical approach does not change the conclusions of the analysis.

[3] Solve for p_0 in terms of the parameters by equating equations (1) and (2); solve for p_1 in terms of the parameters by equating equations (1) and (3); the value of the ratio of p_0/p_1 can be approximated as equation (4) using a Taylor's expansion; substituting equation (4) into equation (3) and again using a Taylor's expansion gives equation (5).

(8) area BOQ_1 − area AOQ_0 =

$$[p_1q_1 - \int_0^{p_1} (1 + k)bp^\beta \, dp]$$

$$- (p_0q_0 - \int_0^{p_0} bp^\beta dp)$$

$$\cong p_0q_0 \frac{k^\beta(\eta - 1)}{(1 + \beta)(\beta + \eta)}.$$

Since the price elasticity of demand (η) for the basic staple cereals is small, certainly less than one, cost of production will decline.

Thus, with technological progress, the cash income of producers (income accrued to producers' owned factors) will change by

(9) Change in cash revenue − change in cost

$$\cong p_0q_0k \frac{\eta - r + \beta(1 - \eta)}{(1 + \beta)(\beta + \eta)},$$

which indicates that the gains of producers will be larger if r is smaller, i.e., if the production of the crop is less commercialized.

The above relations clearly indicate that technological progress in the production of a subsistence crop in a less commercialized closed economy would not only benefit consumers but also is likely to benefit producers.

Distribution among Producers

The right-hand diagram in figure 1 illustrates the changes in equilibrium points of two types of individual farm producers corresponding to changes in market equilibrium point in the left-hand diagram. The supply curves of small and large farms are represented by $O'S_0^S$ and $O'S_0^L$, respectively, before the technological advance, which correspond to OS_0 in the left-hand diagram. The supply schedules of the small and large producers after the change in technology (OS_1) are represented by $O'S_1^S$ and $O'S_1^L$. It is assumed here for convenience that the quantity of home consumption is the same for both small and the large farmers, which does not affect the essence of the argument.

Corresponding to the technological change and the change in market prices, the equilibrium of the small producer moves from A^s to B^s, with the corresponding changes in cash revenue by area $B^sE^sQ_0^sQ_1^s$ − area $A^sC'G'E^s$ and in cost by area $B^sO'Q_1^s$ − area $A^sO'Q_0^s$. Likewise, the equilibrium of the big farmer moves from A^L to B^L, accompanied by the changes in cash revenue by area $B^LE^LQ_0^LQ_1^L$ − area $A^LC'G'E^L$ and in cost by area $B^LO'Q_1^L$ − area $A^LO'Q_0^L$. The net effect on producers' income depends on the relative changes in revenue and cost, which in turn depend on the price elasticities of supply of individual producers' relative to the aggregate demand elasticity.

The aggregate price elasticity of supply (β), which determines the market prices (in the left-hand diagram), is the weighted average of the price elasticities of supply of individual producers, i.e., $\beta = \sum_i w_i\beta_i$, where β_i is the price elasticity of supply of the ith producer ($i = L$ for large producer and $i = S$ for small producer), and w_i is the share of the ith producer in total output. Likewise, the rate of shift in the aggregate supply is an average of the rates of supply shift of individual producers, i.e., $k = \sum_i w_ik_i$.

Applying the same procedures as for the changes in intersectoral income distribution (equations (7) through (9)), approximation formulae for analyzing the impacts of a k% shift in the aggregate supply function on the ith producer are derived as follows:

(10) Change in cash revenue

$$\cong p_0q_{0i}(k_i - k\frac{\beta_i + r_i}{\beta + \eta}),$$

(11) Change in production cost

$$\cong p_0q_{0i}\frac{\beta_i}{1 + \beta_i}(k_i - k\frac{1 + \beta_i}{\beta + \eta}),$$

and

(12) Change in income

$$\cong p_0q_{0i}(k_i - \frac{k_i\beta_i}{1 + \beta_i} - \frac{kr_i}{\beta + \eta}),$$

where q_{0i} and r_i represent, respectively, the output and the marketable surplus ratio of the ith producer before the shift in the supply function. Equations (10) through (12) reduce to equations (7) through (9) if $k_i = k$ and $\beta_i = \beta$.

Whether technical progress in the subsistence crop has a positive effect on the income of the ith producer, i.e., whether equation (12) takes a positive value, depends to a large extent on the magnitudes of k_i and β_i relative to k and β. Clearly, as r_i takes smaller values, the increase in income is larger (or the decline is smaller). In other words, the income position of farmers who sell a small portion of their produce in the market will improve relative to

those who sell a large fraction, given a technical change.

The model is also readily applicable to the analysis of the impact of technical change on the relative incomes of landlords and tenants. If rent is paid in kind as a fixed proportion of output, say, one-half, the supply curve of a tenant can be obtained by shifting the supply curve of an owner-operator horizontally left by 50%. However, if costs are shared in the same proportion by the landlord, the supply curve of the tenant is identical with that of an owner-operator's curve. In this case, the changes in revenue, cost, and income of both landlords and tenants due to the technological change are one-half of the changes in the case of owner-operator, which can be expressed by multiplying equations (10) through (12) by one-half. The major difference between the landlords and the tenants would be expressed by the values of r. The marketable surplus ratio of the small share tenant will be very small, whereas the ratio of the large landlords will be nearly one.

In the case of leasehold tenure, in which the rent is paid in kind in a fixed quantity, the marketable surplus of the tenant is reduced by the quantity of the rent (which could be shown by a rightward shift of $D'_H H'$ in figure 1). Assuming that the landlords sell the whole quantity collected as rent in the market, the aggregate market supply would be the same as in the case of an owner-operator. The change in income of the tenant due to the technical change can be expressed by equation (12) with a smaller value of r. On the other hand, the income of the landlords receiving a fixed quantity of rent in kind would be reduced by the rate of decline in the market price of the produce as expressed by equation (4).

Under the conditions specified, the model demonstrates the fact that technical progress in the production of a subsistence crop has the effect of narrowing the income gap between large farms (or landlords) and smaller farms (or tenants), thereby contributing to a more equal income distribution in the rural sector.

Distribution among Consumers

As shown in equation (6), technical change in production of the subsistence crop represents a clear gain in the economic welfare of urban consumers. The impact of a lowered price of staple food on the welfare and income of urban households depends on the importance of the staple in their expenditure pattern. Poor classes normally consume greater quantities of such products than wealthy; hence, they benefit more.

Suppose that total income (y) is spent either for the food staple (S) or for other commodities (x) as $y = p_s q_s + p_x q_x$, where p_s, p_x, q_s, and q_x represent, respectively, the prices and the quantities of the food staple and the other commodities. Then the percentage change in real income due to a decline in the price of the food staple can be approximated by

$$\frac{\Delta y}{y} = e \frac{\Delta p_s}{p_s}, \tag{13}$$

where $e = p_s q_s / y$ is the ratio of expenditure for the food staple to total household income.

According to equation (4), the percentage change in the market price of the subsistence food crop corresponding to a k% shift in the supply curve is $k/(\beta + \eta)$. Therefore, the percentage increase in real income is approximated by

$$\frac{\Delta y}{y} \cong \frac{ek}{\beta + \eta}. \tag{14}$$

Since e is inversely correlated with per capita income, the decline in the price of food staple due to the technical progress in its production has the effect of equalizing income among urban consumers.

Application to Philippine Rice Economy

In this section the model developed previously is applied to the rice economy of the Philippines in order to demonstrate the distributional implications of technical progress in major subsistence crops.

The Philippines represent an especially relevant case for the present analysis. Rice is the most important subsistence crop in the country, planted in about 3 million hectares, more than 30% of total crop area. It is a typical subsistence crop, in contrast with commercial export crops such as sugarcane and coconuts, which are mainly produced for sale. Rice is also the most important food staple, comprising more than 70% of cereal food consumption on a national basis and up to 90% of cereal consumption in some regions.

Because of the establishment of the International Rice Research Institute in the Philippines and the relatively well-developed local

research and extension capacity, the impact of the new technology has been as significant in the Philippines as in any rice-producing country. The area planted in the new high-yielding varieties has exceeded 55% of lowland rice area (Herdt and Wickham). From the very beginning of the development of new rice technology, its impact on income distribution has been a major concern. For example, Ishikawa has observed that the emergence of large commercial rice farms in Central Luzon coincided with the diffusion of high-yielding varieties and attributed the tendency towards polarization to the high cash requirement of the new technology. Thus, the application of this model to the Philippine rice economy is especially relevant.

Intersectoral Distribution

Estimates of the price elasticity of demand for rice by Nasol based on aggregate time-series data range from -0.23 to -0.47 with a mode of -0.3. In this analysis, the values 0.2, 0.3, and 0.4 are used for η in order to assess the impacts of different price elasticities on the results.

The price elasticity of rice supply was analyzed by Mangahas, Recto, and Ruttan. Their estimates of short-run and long-run elasticities are distributed around mean values of 0.3 and 0.5, respectively. In this analysis, 0.3 and 0.5 are used as boundary estimates for β.

On a national basis, average yields of new rice varieties grown under lowland conditions were 11% higher than yields of traditional varieties between 1968 and 1973 (Atkinson and Kunkel). Ten percent is adopted as the value for k, the shift in the aggregate supply function, for convenience of illustration.

National data on the quantity of marketable surplus of rice is not available. A sample survey in Central Luzon, "the rice bowl of the Philippines," conducted by the International Rice Research Institute, provides a beginning approximation (Toquero et al.). An average of 40% of production was sold by farmers. In addition, a major portion of rent in kind (17% of total output) was also probably sold in the market by landlords. However, farmers in Central Luzon are known to sell more on the market than do most Philippine farmers. Therefore, it seems reasonable to assume that the aggregate marketable surplus ratio (r) is 0.4.

The results of applying the specified parameters into equations (4) through (9) are summarized in table 1. A 10% increase in the supply function due to technical progress results in a price decline of 10% to 20% and an increase in quantity of 3% to 6%. Consumers' surplus rises by 4% to 8%, while producers' cash revenue declines slightly. However, the reduction in revenue is more than compensated for by the reduction in production cost, resulting in an increase in the cash income of producers of 1% to 2% (except the case of $\eta = 0.2$ and $\beta = 0.3$).

Calculations using the average price and quantity prevailing in the Philippines between 1969 and 1971 and the most probable values of $\beta = 0.4$ and $\eta = 0.3$ show total benefits of the new technology worth about 150 million pesos per year, with 80% going to consumers and 20% to producers. The effects on income distribution would be quite different in a commercial agriculture. If r is assumed to equal one, consumers gain twice the value of the new income stream—half from the benefits of the lower cost technology and half as a transfer from producers whose losses equal the benefits of the technology.

Table 1. Calculated Percentage Change in Consumers' Surplus and Producers' Income Due to Technical Progress in Rice Production in the Philippines

	Percentage Changes with the Specified Parameters					
	$k = 0.1$			$r = 0.4$		
	$\eta = 0.2$		$\eta = 0.3$		$\eta = 0.4$	
Changes in	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.3$	$\beta = 0.5$
Price	−20.0	−14.3	−16.7	−12.5	−14.3	−11.1
Quantity	4.0	2.9	5.0	3.8	5.7	4.4
Consumers' surplus	8.0	5.7	6.7	5.0	5.7	4.4
Producers' cash revenue	−4.0	−2.8	−1.7	−1.2	0	0
Production cost	−3.7	−3.8	−2.7	−2.9	−2.0	−2.2
Producer's cash income (producers' surplus)	−0.3	1.0	1.0	1.7	2.0	2.2

Hence, while technological progress in a fully commercial agriculture facing an inelastic demand would result in an income transfer from farm producers to urban consumers, technological progress does not have such a strong distributional impact on producers in a semisubsistence agriculture. While a major gain from technological progress in rice production goes to nonfarm consumers, the aggregate income of producers also likely increases.

Distribution within the Rural Sector

The analysis of the impact of new technology on the income distribution among producers is based on equations (10) through (12). The problem reduces to a comparison of changes in revenue, cost, and income of small and large farmers in response to the price decline resulting from the shift in the aggregate supply function.

Large and small farmers differ mainly in the proportion of output they sell (r). The earlier study mentioned indicated that about half the sample farmers in Central Luzon sold less than 25% of their produce, and less than 5% of the farmers sold more than three-quarters. For the sake of illustration, $r = 0.2$ is assumed for small farms and $r = 0.8$ for the large farms.

There is no empirical evidence that there are differences in the adoption of technical progress in rice production (k) and in the price elasticity of rice supply (β) among small and large farmers in the Philippines. Rather, the available evidence seems to support the hypothesis that there is no significant difference in the rate of diffusion of the new high-yielding varieties and in the resulting increase in yield between the small and the large producers (Mangahas, Miralao, and de los Reyes; International Rice Research Institute). Considering the highly divisible nature of the new seed-fertilizer technology, it seems reasonable to expect that the technical progress has been neutral with respect to farm scale. However, in order to test the effect of differential rates of technical progress, an analysis was carried out based on two alternative assumptions: (*a*) the same shift from technical progress for different size classes ($r_s = r_L = r = 10\%$), and (*b*) a shift from technical progress of the larger farmers twice that of the small farmers ($r_s = 7$, $r_L = 14$, and $r = 10\%$).

There is also a possibility that larger farmers with a greater capacity for investment financing find it easier to adjust their production to the long-run equilibrium point. Considering such a possibility, two further alternative assumptions are specified: (*a*) both the large and the small farmers have the same price elasticity of supply ($\beta_s = \beta_L = \beta = 0.4$), and (*b*) the supply elasticity of the large farmers reach the long-run level, while the elasticity of the small farmers remains at the short-run level ($\beta_s = 0.3$, $\beta_L = 0.5$, and $\beta = 0.4$).

Four cases occur from the possible combinations of values of k_i and r_i. The results are summarized in table 2. In all cases, technical progress improves the income position of small farms while that of the large farms deteriorates. In cases 1 and 2, the 10% shift in the supply function increases the incomes of small farms and reduces the incomes of large farms by more than 4%, respectively. However, even when the shift from technical prog-

Table 2. Calculated Differential Impacts of Technical Progress in Rice Production on Small and Large Farmers in the Philippines

	Parameters Specified			Percentage Changes in		
	$k = 0.1$	$\eta = 0.3$	$\beta = 0.4$	Cash	Production	Cash
	r_i	β_i	k_i	Revenue	Cost	Income
Case 1						
Small farms	0.2	0.4	10	1.4	−2.9	4.3
Large farms	0.8	0.4	10	−7.1	−2.9	−4.2
Case 2						
Small farms	0.2	0.3	10	2.9	−2.0	4.9
Large farms	0.8	0.5	10	−8.6	−3.8	−4.8
Case 3						
Small farms	0.2	0.4	7	−1.4	−3.7	2.3
Large farms	0.8	0.4	14	−3.1	−1.7	−1.4
Case 4						
Small farms	0.2	0.3	7	−0.1	−2.7	1.6
Large farms	0.8	0.5	14	−4.6	−2.5	−2.1

ress of large farms is twice that of small farms (cases 3 and 4), the income of the small farms improve and the income of the large farms decline by about 2%, respectively. Improved technology is a force tending to equalize incomes among rice producers.

The results also provide insight on the relative changes in income position between tenants and landlords as discussed above simply by regarding small farms as tenants and large farms as landlords. However, the income-equalizing effect of the new technology between tenants and landlords is likely much greater than shown because r for most share tenants is smaller than 0.2 and r for large landlords must be close to 1.0.

Distribution among Nonfarmers

As shown earlier, the major gains in economic welfare from the development of new rice technology are captured by nonfarm consumers. Their gains vary with the fraction of total expenditure devoted to rice. By applying data on the share of rice in the total expenditure of urban households for different income classes in the Philippines (Bureau of Census and Statistics) to equation (14) with $\beta = 0.4$ and $\eta = 0.3$, the differential impacts of technical change on the real income of urban households were calculated. A 10% shift in the rice supply function results in a 4% increase in real income for households with less than 1,500 pesos annual income (about $250). The same change increases the real income of the highest income classes with more than 15,000 pesos annual income by only 1%. The relative gain in real income is larger for the households of low-income workers. These benefits of new rice technology are not only captured by urban workers but also by landless farm workers for whom rice is a major item of household expenditure.

Relaxing the Assumption of Fixed Home Consumption

The most restrictive assumption in the preceding analysis is that of fixed home consumption of the commodity by farmers' households. There have been few attempts to estimate the price response of home consumption. A recent study for rice in the Philippines based on a sample survey of the same farmers for three consecutive years shows that the effect of price changes on home consumption of rice is not statistically significant and home consumption rises significantly in response to increases in output, although it tends to level off at high outputs. The results of the regression analysis were confirmed by a motivation survey on the disposition of rice output (Toquero et al.).

At least in the case of rice in the Philippines, it is reasonable to assume that home consumption is not price responsive and can be approximated by a vertical line such as D_HH in figure 1. However, D_HH does not stay stable but shifts to the right as output increases OQ_0 to OQ_1. The rightward shift in the home consumption schedule implies a shift to the right in the total demand schedule by the same amount, as represented by the shifts from D_HH to $D_H^*H^*$ and from D_HD_MD to $D_H^*D_M^*D^*$ in figure 2. Corresponding to this shift, the market equilibrium after the introduction of new technology will be established at B^* instead of at B.

The consumers' surplus (of nonfarm consumers), assuming the increase in home consumption in response to output increase, is represented by area $B^*D_M^*G^*$. Since $D_H^*D_M^*D^*$ is parallel with D_HD_MD, area $B^*D_M^*G^*$ is equal to area WD_MZ. Therefore, the increase in consumers' surplus due to the technical change under the assumption of fixed home consumption by producers' households is larger than when home consumption increases in response to output increases by area $BWZG$.

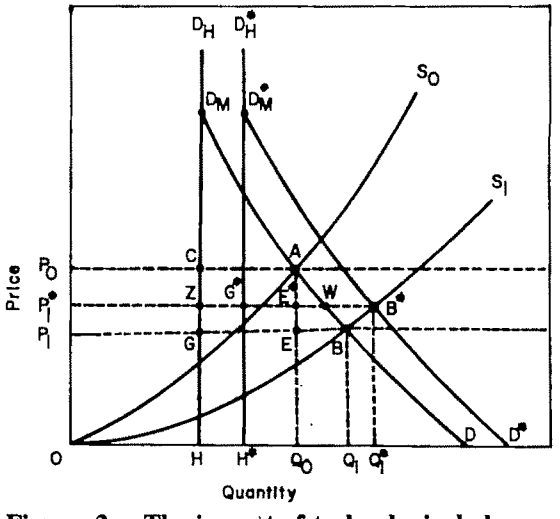


Figure 2. The impact of technological change in a subsistence crop under the assumption of variable home consumption

Correspondingly, the assumption of the fixed home consumption is likely to produce an overestimation of producers' cash revenue by the difference between area $B^*G^*H^*Q_1^*$ − area $ACHQ_0$ and area BEQ_0Q_1 − area $ACGE$ and to produce an underestimation of the cost of production by area $BQ_1Q_1^*B^*$.

Define m as the percentage shift in the total demand function corresponding to the increase in home consumption (Δh), i.e.,

$$(15) \qquad m = \frac{HH^*}{OQ_0} = \frac{\Delta h}{q_0} \cong \frac{\Delta q}{q_0}\delta(1 - r),$$

where $\delta \left(= \frac{\Delta h}{\Delta q}\frac{q}{h}\right)$ is the elasticity of home consumption with respect to output. Assuming that m is approximately constant for the relevant range of analysis, the total demand schedule ($D_H^*D_M^*D^*$) can be approximated by

$$(16) \qquad q = c(1 + m)p^{-\eta}.$$

The equilibrium price and quantity after the change in technology and including the adjustment in home consumption resulting from the output increase can be obtained by solving the simultaneous system consisted of equations (3) and (16) as follows:

$$(17) \quad p_1^* \cong p_0\left(1 - \frac{k}{\beta + \eta} + \frac{m}{\beta + \eta}\right)$$

and

$$(18) \quad q_1^* \cong q_0\left(1 - \frac{\eta k}{\beta + \eta} + \frac{\beta m}{\beta + \eta}\right).$$

Correspondingly, the changes in consumers' surplus, producers' cash revenue, and production cost due to the change in technology are recalculated for the case of variable home consumption as

(19) Change in consumers' surplus

$$= \text{area } WD_MZ - \text{area } AD_MC$$
$$\cong p_0q_0\left(\frac{kr}{\beta + \eta} - \frac{mr}{\beta + \eta}\right),$$

(20) Change in producers' cash revenue

$$= \text{area } B^*G^*H^*Q_1^* - \text{area } ACHQ_0$$
$$\cong p_0q_0\,\frac{k(\eta - r)}{\beta + \eta} - \frac{m(\eta - r) - m(k - m)}{\beta + \eta},$$

and

(21) Change in production cost

$$= \text{area } B^*OQ_1^* - \text{area } AOQ_0$$
$$\cong p_0q_0\left[\frac{k\beta(\eta - 1)}{(1 + \beta)(\beta + \eta)} + \frac{\beta m}{\beta + \eta}\right].$$

The second terms of each expression represents the additional effect when the assumption of fixed home consumption is relaxed.

In order to evaluate the effect, the value of m is required. Equation (18) implies

$$(22) \qquad \frac{\Delta q}{q_0} \cong \frac{\eta k + \beta m}{\beta + \eta}.$$

Substitution of the above expression into equation (15) yields

$$(23) \qquad m \cong \frac{k\eta\delta(1 - r)}{\beta + \eta - \beta\delta(1 - r)},$$

which is calculated as 1.2% for the following values of the parameters: $\eta = 0.3$, $\beta = 0.4$, $k = 10\%$, $r = 0.4$, and $\delta = 0.4$.[4]

Calculations of the consumers' surplus and producers' cash income for the two assumptions about producers' home consumption are compared in table 3. The assumption of fixed home consumption may contribute to a small overestimation of consumers' gains. The welfare loss of producers from the reduction in

[4] Specification of δ is based on Toquero et al.

Table 3. Calculated Percentage Changes in Consumers' Surplus and Producers' Income Due to Technical Progress in Rice Production for Two Assumptions on Producers' Home Consumption

Change in	Fixed Home Consumption	Variable Home Consumption	Variable Minus Fixed Home Consumption
Price	−14.3	−13.6	1.7
Quantity	4.3	5.0	0.7
Consumers' surplus	5.7	5.0	−0.7
Producers' cash revenue	−1.4	−1.1	0.3
Production cost	−2.8	−2.3	0.5
Producers' cash income	1.4	1.2	−0.2
Producer's' home consumption	0	2.0	2.0

Note: The variables are assumed to have the following values: $\eta = 0.3$, $\beta = 0.4$, $k = 0.1$, $r = 0.4$, and $\delta = 0.4$.

cash income seems more than compensated for by increased home consumption. The magnitude of possible effects on consumers' welfare and producers' cash income are sufficiently small so that the basic conclusion on intersectoral income distribution is not affected. Also, since the effect on prices is small, the conclusion on income distribution within the urban sector remains unaltered.

Consider the implications of the assumption of fixed home consumption on the income distribution between large and small farmers. Individual farmers will try to maximize their profit for the market price determined by equation (17). Since the elasticity of home consumption of rice with respect to output declines as output rises, the rate of increase in home consumption corresponding to the increase in output due to technical progress would be different for large and small farmers; it is likely to be smaller for large farmers than for small farmers. The percentage increase in aggregate home consumption in response to the increase in aggregate rice output is the weighted average of the percentage for the large and small producers, i.e., $m = \Sigma w_i m_i$.

Applying the same procedures as for the case of fixed home consumption, a formula was derived for analyzing the impacts of change in technology on the ith producer for the assumption of variable home consumption as follows:

(24) Change in cash revenue

$$\cong p_0 q_0 \left[k_i - \frac{k(\beta_i + r_i)}{\beta + \eta} - m_i + \frac{m(\beta_i + r_i)}{\beta + \eta}\right],$$

and

(25) Change in production cost

$$\cong p_0 q_0 \frac{\beta_i}{1 + \beta_i}\left(k_i - k\frac{1 + \beta_i}{\beta + \eta} + m\frac{1 + \beta_i}{\beta + \eta}\right),$$

where m_i is defined as

$$(26) \qquad m_i = \frac{\Delta hi}{q_{oi}} = \frac{\Delta q_i}{q_{oi}}\,\delta_i(1 - r_i),$$

where q_{oi} and r_i are the quantity of total output (= consumption) and the marketable surplus ratio before the introduction of new technology, respectively; Δq_i and Δh_i are the changes in the quantities of total output and home consumption due to the introduction of the technology; and δ_i is the output elasticity of home consumption of the ith producer.

Since individual producers increase output along their supply schedules in response to the change in market price from p_0 to p_1^*, which is given by equation (17), the rate of increase in output can be approximated by

$$(27) \qquad \frac{\Delta q_i}{q_{oi}} \cong k_i \frac{\beta_i (m - k)}{\beta + \eta}.$$

The variable m_i is given as

$$m_i = \left[k_i + \frac{\beta_i (m - k)}{\beta + \eta}\right]\delta(1 - r_i).$$

The different estimates of the impacts of technical progress on large and small farmers for different assumptions on producers' home consumption behavior are compared in table 4. For the case of variable home consumption, the home consumption of small producers is assumed to be highly responsive to output increases with $\delta_s = 0.6$, whereas the home consumption of large producers is in saturation, i.e., $\delta_L = 0$.

Compared with the case of fixed home consumption, the favorable impact of the technical change in promoting a more equal distribution of cash income is less dramatic if changes are allowed in home consumption for small producers. However, even in case 4 with the higher rate of technical progress and the larger capacity for supply adjustment of larger farmers, the impact of technical progress on the distribution of cash income is in the direction of promoting equality. While small farmers' cash income position stays fairly stable, larger farmers incur substantial losses. Economic welfare of small farmers clearly increases since their consumption of rice increases (last column of table 4), while their cash income remain nearly constant.

The results of table 4 show clearly that, if the specification of δ's is correct, technical progress in rice production will contribute to the welfare of small producers by increasing their rice consumption and will result in a reduction of income to large commercial farmers and/or landlords; the part of their income reduced will be transferred to the urban poor and the landless rural workers in the form of a lowered price of the basic consumption good. Thus, the conclusion that technical progress in the production of subsistence crops in a semisubsistence economy has the effect of

Table 4. Calculated Percentage Change in Consumers' Surplus and Producers' Incomes for Small and Large Farmers with Two Assumptions on Producers' Home Consumption (Percentage Change)

	Fixed Home Consumption Case[b]			Variable Home Consumption Case[c]			
	Cash Revenue	Production Cost	Cash Income	Cash Revenue	Production Cost	Cash Income	Home Consumption
Case 1[a]							
Small farms	1.4	−2.9	4.3	0	−0.5	0.5	3.0
Large farms	−7.1	−2.9	−4.2	−5.1	−0.5	−4.6	0
Case 4[a]							
Small farms	−0.1	−2.7	1.6	−0.7	−0.2	−0.5	1.9
Large farms	−4.6	−2.5	−2.1	−3.4	−0.2	−1.4	0

[a] Parameter specifications are the same as for table 2.
[b] Assume $\delta = \delta_S = \delta_L = 0$.
[c] Assume $\delta = 0.4$, $\delta_S = 0.6$, and $\delta_L = 0$.

promoting a more equal distribution of income and welfare remains unchanged, even if the restrictive assumption of fixed home consumption by producers' households is removed.

Conclusion and Implications

The model and its application to the Philippine rice economy indicate that modern technology, such as the high-yielding rice varieties, benefits both consumers and producers. Within agriculture, it has an effect of promoting a more equal income distribution through downward pressure on prices and hence on the incomes of those farmers with a large proportion of marketed surplus. It tends to transfer income from large commercial farmers and landlords to the urban poor and the rural landless classes.

Between 1967 and 1970, when real rice prices fell by about 20% in the Philippines, the above forces were at work.[5] In more recent years, the supply function has not kept pace with the shifts in demand, resulting in sharp increases in rice prices. These increases have had an especially adverse impact on the level of living of low-income working classes. The rising prices have also provided large windfall gains to large producers who sell a major portion of their output, while providing little benefit to small semisubsistence farmers.

In fact, these phenomena represent the reverse of the results obtained in the model under the assumption of a rightward shift in the supply function with a stable demand function. In recent years the demand function has shifted faster than the supply function, resulting in sharp increases in staple food prices. In effect, technology has not shifted the supply curve fast enough. However, unless the supply function had been shifted by earlier developments in technology, the level of rice prices would have been higher, the increase might have occurred sooner, and the adverse effects of rising prices on income distribution would have been much greater.

The analysis suggests that a critical factor for attaining a more equal income distribution in the developing economies is the intensification of efforts for developing improved technology for the subsistence crop sector to enable the supply function of major food staples to shift more rapidly than the demand. However, this does not imply that technological advances can solve the whole problem. On the contrary, the data in tables 2 and 4 show that, if technical progress is slower for the small farmers than the large farmers, relative income gains for small farmers are reduced. A real danger would arise if new technology was monopolized by a small number of large producers, without causing a significant shift in the aggregate supply schedule. In such a case, the large farmers could capture the whole gain of technical progress by increasing output without a resulting decline in prices.

Likewise, if the large commercial farmers in a subsistence country exert their political power to have prices supported at the preinnovation level, then the benefits are captured

[5] Rice prices averaged 15.21 pesos per cavan (a measure of 44 kilograms) in 1967 and 14.95 pesos per cavan in 1970, while the consumer price index for areas outside Manila went from 106.2 to 129.7.

by those with a large marketed surplus at the expense of the taxpayers who bear the cost of price supports. (This does not occur with price stabilization programs designed to smooth out fluctuations within a year.)

It should also be reemphasized that this analysis abstracts from the possible changes in factor shares or factor ownership that might occur either as a result of technological change or at the same time but for independent reasons. The final impact of such changes on the income distribution would reflect the net effect of the new factor shares and factor ownership distribution, as well as the real income effects discussed above.

There are a number of conditions that might prevail in which the income distribution after the introduction of technological change might be more inequitable than the distribution before such an introduction. In order to avoid such a possibility, efforts should be strengthened to facilitate the adoption of technological innovations by small farmers. Improvements in public services for extension, credit, and marketing should be directed to this purpose. Especially critical is the provision of indivisible factors, such as irrigation, that may be too large for purchase by individual small farmers. However, all those efforts will not be effective in promoting a more equal income distribution in developing economies unless research and development are strengthened so that the rate of shift in the supply of the major subsistence crops can exceed the rate of shift in the demand for them.

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Regional Differences in Agricultural Productivity in Selected Areas of India

K. William Easter, Martin E. Abel, and George Norton

Production functions are used to measure the contribution to agricultural output of infrastructure and the quantity and quality of traditional inputs. Measuring the contributions of inputs over time together with an assessment of their supply provide insights into the direction that agricultural development efforts should take in two regions of India. In the wheat region, continued increases in the quantity and quality of irrigation and improved crop varieties are promising sources of output growth. For the rice region, the development of rural roads and markets, increases in irrigation quality, and improved rice varieties are important sources of output growth.

Key words: agricultural productivity, India, regional differences, restraints, rice, wheat.

Earlier work by the authors strongly suggests that the restraints to changing the level and distribution of agricultural output vary among regions of a country (Abel and Easter, Easter 1972, Easter and Singh). Recent work by Herdt, De Datta, and Neely supports this view. Agricultural development efforts can be improved if the relevant restraints within agricultural regions of a country are properly identified and development programs are focused on removing them. Qualitative and quantitative differences in resource endowments among regions dictate different types of technological development as well as different development strategies.

The focus of this analysis is to measure, by use of production functions, the contribution to total output of not only the quantity of traditional inputs (land, labor, fertilizer, etc.) but also the quality of certain inputs, particularly irrigation, technology, environmental factors (soil types, rainfall, etc.), and infrastructure (transportation, markets, etc.). Identification and measurement of the contribution to output of different types of inputs together with assessments of their supply provide valuable insights into the direction that agricultural development efforts should take in different regions of a country. Certain factors affecting output, such as soils or climatic conditions, may be fixed, and production technology has to adjust to them. Other factors such as the quantity and quality of irrigation or infrastructural investments may have varying elasticities of supply. The possibility and cost of expanding the supply of such inputs may vary considerably among regions. Strategies for increasing agricultural output and productivity should incorporate the different factor supply responses among regions.

The analysis covers two regions in India. One, defined as the wheat region, comprises seventy-three districts in the states of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, and Rajasthan. These districts account for the bulk of total wheat production in India. The other region is the eastern rice region, consisting of sixty-nine districts in eastern Uttar Pradesh, Bihar, West Bengal, Orissa, and eastern Andhra Pradesh (Easter and Abel).[1] The unit of observation is the district. A list of

K. William Easter and Martin E. Abel are professors and George Norton is a research assistant in the Department of Agricultural and Applied Economics, University of Minnesota.

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[1] Assam is not included in the analysis because of the nonavailability of data.

the districts is contained in Easter, Abel, and Norton.

Data are available for a ten-year period, 1959–60 through 1968–69, for all of the districts for value of crop output, crop area, irrigation, and fertilizer. In addition, data for tractors and labor are obtained for the ten-year period by interpolating and extrapolating trends based on two census years.[2] (See appendix for sources for these data.) One would like to make use of the entire time series of cross-section data. However, trying to explain productivity differences among districts using only the above variables would undoubtedly lead to seriously biased estimates because (*a*) some of the above variables, such as land and irrigation, do not reflect variations in the quality of these inputs and (*b*) there are other factors specific to each district that are not reflected in the above data and for which time-series data do not exist.

A three-stage procedure is used to improve the specification of the estimated production functions. The first stage involves estimation of production functions from a ten-year time series of cross-section data using an error components model. This model allows calculation of regional effects for the districts that represent systematic variation in productivity levels among districts not explained by variations in the inputs used in the error components model. The calculated regional effects are summary measures of the effect on output of factors not included in the error components model. In the second stage, an attempt is made to explain variations in regional effects by a variety of factors not included in the original production function. Finally, production functions are estimated including these additional factors for 1959/60–1961/62 and 1967/68–1968/69 when data on more of the relevant variables are available. Only these latter estimates are reported in detail here. (Definitions of the variables used in the following sections are found in the appendix.)

Regional Effects

In analyzing a time series of cross-section data, one can employ an error components model to isolate effects that are specific to a region and relatively time invariant. (A more detailed discussion of the application of the error components model and the calculated regional effects is found in Easter, Abel, and Norton.) These effects are normally captured in either the error term or the coefficients of the nonregional specific variables in ordinary regressions applied to the total set of data. The error components model is discussed and applied by Balestra and Nerlove, Nerlove (1971a, b), Schultz (1969, 1973), and Mukhopadhyay.

The error components model is applied to both the wheat and rice regions using a time series of cross-section data in which crop output is regressed on crop area, irrigated area, fertilizer, tractors, and labor.[3] These independent variables explain 24% of the variation in the value of crop output in the wheat region and 31% in the rice region. For both the wheat and rice regions, the ranking of districts by the value of the calculated regional effects corresponds very closely to the ranking of districts by either output per hectare or by the importance of a district measured in terms of its contribution to total national production of either wheat or rice as calculated by Easter and by Easter and Abel.

The second stage involves regressing the estimated regional effects on a number of variables thought to be important determinants of productivity. In the wheat region, the quality of irrigation,[4] measured by either the tubewell or irrigation index variables, soil types, and rainfall are important explanatory variables.[5] These variables explain about 55% of the variation in the regional effects for the wheat region, with tubewells being the dominant explanatory variable. In the rice region, pumpsets,[6] soil types, rainfall, work animals,

[2] Data on other variables, such as work animals, can be derived from census data in a similar manner. However, use of these additional variables leads to serious problems of intercorrelation among several of the independent variables.

[3] An attempt is made to capture the effects of education by using literate and illiterate labor variables in place of total labor. However, literate and illiterate labor variables are very highly correlated, giving rise to serious problems of intercorrelation between these two independent variables.

[4] Farmers with tubewells have greater control over the timing of irrigation and the amount of water applied than do those using canal irrigation. We would expect tubewell irrigation to be more productive than canal irrigation.

[5] Several other variables are examined for the wheat region but are found to be statistically nonsignificant or so highly correlated with other independent variables as to result in statistically insignificant estimates of some of the coefficients. Work animals do not have a significant coefficient. Surfaced roads are not an important variable, probably because most of the wheat region had a reasonably well-developed system of roads during the period of analysis. A measure of research expenditures by district, developed by Evenson, is not significant. Finally, area planted to high-yielding varieties of wheat is insignificant because it is highly correlated with fertilizer and particularly tubewells.

[6] Most of the irrigation in the eastern rice region is surface

and surfaced roads are important variables.[7] These variables account for about 80% of the variation in the regional effects.

Productivity Analysis

The insights gained from the analysis of regional effects are used to formulate the production functions for the wheat and rice regions. It is not possible to utilize the ten-year time series of cross-section data because observations for the full period are not available for all the variables. Furthermore, estimation of data for some of these variables by interpolation and extrapolation from census data is undesirable because there is no reason to expect some variables to behave in a trend-like way and development of too many variables in this fashion results in serious problems of intercorrelation among independent variables. Consequently, the data used are three-year averages for the period 1959/60–1961/62 and two-year averages for 1967/68–1968/69. A two-year average is used for the latter period, since 1966–67 was an unusually dry year and data are not available for 1969–70. Weather conditions for the years employed are considered to be reasonably normal.

Wheat Region

Equations (1) through (4) in table 1 are for the 1959/60–1961/62 period. Equation (1) contains the five independent variables used in the error-components analysis. All of the coefficients are significant. The addition of work animals in equation (2) results in a significant but negative coefficient for labor.[8] This is due

irrigation. Easter (1974) has shown that the quality of surface irrigation systems is important in determining agricultural productivity. Unfortunately, data are not available to measure either variations in the quality of surface irrigation or in the number of tubewells. Instead, the number of pumpsets is used as a measure of the quality of irrigation.

[7] In contrast to the wheat region, surfaced roads are a highly significant variable. Two reasons explain this difference. First, traditional rice-growing areas are heavy rainfall areas, and it is difficult to transport inputs or products during the rainy season without adequate roads. Second, many parts of the eastern rice region have poorer roads compared with the wheat region.

[8] A measurement problem may exist with the labor variable. The variable represents the stock of labor available in each dis-

Table 1. Regressions of the Total Value of Crop Output on Selected Independent Variables, Wheat Region

Independent Variable	1959/60–1961/62 Average				1967/68–1968/69 Average			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop area	0.512	0.607	0.893	0.852	0.431	0.463	0.544	0.427
	(5.278)	(8.025)	(6.552)	(5.857)	(4.280)	(4.508)	(4.660)	(3.414)
Irrigated area	0.059	0.097	0.067		0.100	0.111	0.054	
	(2.922)	(5.933)	(2.716)		(3.294)	(3.552)	(1.276)	
Fertilizer	0.093	0.092	0.074	0.098	0.071	0.074	0.037	0.079
	(4.290)	(5.547)	(3.011)	(3.890)	(3.051)	(3.194)	(1.022)	(2.050)
Tractors	0.132	0.125	0.093	0.093	0.167	0.168	0.131	0.139
	(4.264)	(5.279)	(3.026)	(2.819)	(6.258)	(6.340)	(5.195)	(5.018)
Labor	0.152	−0.310	−0.130	−0.118	0.263	0.101	0.181	0.246
	(1.929)	(−3.449)	(−1.193)	(−1.009)	(3.120)	(0.700)	(1.979)	(2.472)
Total rainfall			0.296	0.300			−0.050	−0.101
			(2.891)	(2.748)			(−0.761)	(−1.425)
Black soils			−0.207	−0.196			0.096	0.159
			(−2.407)	(−2.118)			(1.021)	(1.537)
Alluvial soils			−0.002	−0.005			0.108	0.227
			(−0.018)	(−0.050)			(1.074)	(2.143)
Tubewells			0.044				0.069	
			(3.408)				(4.088)	
Irrigation index				0.082				0.068
				(3.060)				(1.415)
Work animals		0.489				0.155		
		(6.937)				(1.375)		
Constant	1.560	−0.216	−0.947	−0.813	0.546	0.108	1.481	1.522
$\bar{R}^2$	0.902	0.942	0.923	0.912	0.909	0.910	0.934	0.919

Note: *t*-values are in parentheses for the two-tailed test.

to the high intercorrelation between work animals and labor. Inclusion of work animals also increases the irrigated area and crop area coefficients. The addition of the soil dummy variables (of which black soils is significant), total rainfall, and tubewells has the effect of increasing the coefficient of crop area, reducing the size of the coefficients of irrigated area and fertilizer, and making the coefficient of labor negative but insignificant. The tubewell variable is correlated with both irrigated area and fertilizer, which may explain the decline in the size of the coefficients of these latter two variables in equation (3). To get around this problem, the irrigation index, a combined measure of irrigated area and quality of irrigation, is used in equation (4). This measure is statistically significant and results in a significant and larger coefficient for fertilizer than when tubewells and irrigated area are included as separate variables.

Similar analyses for the period 1967/68–1968/69 are contained in equations (5) through (8). The behavior of the coefficients in this set of equations with respect to alternative specifications is similar to that in equations (1) through (4). In this latter period the interaction between the fertilizer variable and the measures of irrigated area and irrigation quality are even more evident with the coefficients of the latter two variables being smaller and statistically insignificant in equation (7) compared with the other equations. In addition, the alluvial soils dummy becomes significantly positive in equation (8), indicating that alluvial soils become more productive relative to the other soil types with increases in irrigation, fertilizer use, and the associated use of new wheat varieties. The negative coefficient for total rainfall is due to the fact that irrigation has developed more rapidly in the drier parts of the wheat region.

A comparison of the results for 1959/60–1961/62 with those for 1967/68–1968/69 helps highlight some of the changes that have occurred. During this period there was a fairly rapid adoption of high-yielding varieties of wheat. By 1968–69, 48.5% of the total wheat area in the Punjab was planted to high-yielding varieties, 48.0% in Uttar Pradesh, 28.9% in Haryana, 16.4% in Rajasthan, and 2.7% in Madhya Pradesh (table 2). The districts comprising the wheat region fall within these five states. These adoption rates reflect a rather rapid rate of technological change.[9]

Comparing equations (3) and (7) and equations (4) and (8) in table 1, one sees that there are some rather sizable changes in the production coefficients associated with the introduction of the new varieties of wheat. The new technology has the effect of decreasing the coefficient of land, increasing the coefficients of tractors, labor, and tubewells, and decreasing the coefficients of fertilizer and irrigated area with both becoming insignificant in the latter period. When the irrigation index is used in place of tubewells, the coefficient of fertilizer remains significant, although the coefficient of the irrigation index itself is nonsignificant.

A Chow test is used to test if regressions (3) and (4) are significantly different from regressions (7) and (8), respectively. The calculated values of the F-statistic are 3.05 for the comparison of regressions (3) and (7) and 3.23 for the comparison of regressions (4) and (8). The hypothesis that the regressions are not different is rejected at the 1% level of significance for each comparison.

The calculated marginal products of the relevant independent variables corresponding to the equations in table 1 are given in table 3. Comparing the 1967/68–1968/69 period with 1959/60–1961/62, the following is observed. The marginal productivities of land, irrigated area, tubewells, and fertilizer decline, while

trict, not the amount of labor actually used. It may not be too unreasonable to assume that the difference between labor available and labor actually used is negatively related to output per hectare; i.e., high productivity districts make fuller use of available labor than low productivity districts. Such systematic measurement error would lead to a downward bias in the estimated labor coefficients.

[9] Area planted to high-yielding varieties of wheat is included as an independent variable in the 1967/68–1968/69 equations. However, because high-yielding varieties are highly correlated with fertilizer and irrigation, either the coefficient of varieties or the coefficients of fertilizer and irrigation are insignificant, depending upon the specification of the equations. The high-yielding varieties are, therefore, dropped, since of the three variables it is the only one that cannot be used in the early period.

Table 2. Percentage of Wheat Area Planted to High-Yielding Varieties by States, 1966–67 to 1968–69

State	1966–67	1967–68	1968–69
		%	
Haryana	1.8	12.0	28.9
Madhya Pradesh	0.8	1.7	2.7
Punjab	3.6	35.4	48.5
Rajasthan	1.0	9.9	16.4
Uttar Pradesh	8.3	31.9	48.0

Source: Abel.

Table 3. Marginal Products, Wheat Region

Independent Variable	1959/60–1961/62 Average				1967/68–1968/69 Average			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop area	0.185	0.219	0.323	0.308	0.172	0.184	0.217	0.170
Irrigated area	0.154	0.253	0.175	—	0.194	0.216	0.105	—
Fertilizer	58.27	57.64	46.37	61.40	4.81	5.01	2.50	5.35
Tractors	137.22	129.94	96.67	96.67	128.51	129.28	100.81	106.96
Labor	0.076	−0.155	−0.065	−0.059	0.151	0.058	0.104	0.141
Total rainfall	—	—	477.83	484.29	—	—	−95.06	−192.02
Tubewells	—	—	15,480.8	—	—	—	4,460.2	—
Irrigation index	—	—	—	0.207	—	—	—	0.197
Work animals	—	0.337	—	—	—	0.121	—	—

Note: Marginal products: change in the value of crop output in thousand rupees of a one-unit change in the independent variable. For example, according to equation (3), a one-hectare increase in crop area increases the value of output by 323 rupees (in terms of 1959/60–1961/62 average prices).

those for tractors increase slightly and those for labor increase substantially. The calculated changes in the marginal products are the results of both a change in technology and a change in the mean values of the independent variables, the two types of change reinforcing each other in some cases and offsetting each other in other cases. These two types of changes result in an increase in average crop output per district from Rs. 137.216 million for the 1959/60–1961/62 period to Rs. 161.600 million in the 1967/68–1968/69 period.

It is plausible to expect the new technology to lower the marginal product of land because it is land augmenting in nature. The geometric mean value of crop area per district also increases from 379,487 hectares to 405,889 hectares, which would *ceteris paribus* decrease the marginal product of land.

The new technology is dependent upon quality irrigation and fertilizer. It would not be unreasonable to expect the marginal products of both to increase. However, a decline is observed. The positive effect of technology on the marginal production may be more than offset by increased average use of these inputs. The geometric mean value per district of irrigated area increases from 52,561 hectares to 83,180 hectares, the irrigation index goes from 54 to 92, and the tubewell measure increases from 0.0039 to 0.025. The use of fertilizer increases dramatically from 219 metric tons per district to 2,387 metric tons. This increase reflects not only a higher productivity of fertilizer but a substantial decline in its price relative to the price of wheat. Over the study period the ratio of the wholesale price of wheat to the wholesale price of urea increases from 0.62 to 1.12, or by 80%.

While the new technology seems to increase the marginal productivity of tractors slightly, its effect on increasing the marginal productivity of labor appears to be substantial, even with an increase in average labor available per district from 273,758 to 282,095 workers.

Rice Region

The regression results for the rice region presented in table 4 are organized in a similar way to those for wheat in table 1.

One of the striking results in all equations is the insignificance of irrigation. Most irrigation systems in the rice region have little reservoir capacity and are heavily dependent upon rainfall and diverted stream flow. This may be the main reason why irrigated area yields nonsignificant results. The effect of irrigation is being picked up by the total rainfall variable, which is significant. June and October rainfall were tried in place of total rainfall, and these variables also had significant coefficients.

As mentioned earlier, data are not available on tubewells, so this form of irrigation could not be used in developing a measure of quality of irrigation. Data are available on pumpsets, and this measure had positive and significant coefficients for 1959/60–1961/62. Coefficients for pumpsets are negative but insignificant in 1967/68–1968/69. Separate analyses by Easter (1974) for parts of the eastern rice region show that improvement of the quality of irrigation increases production substantially. Better data on and measures of the quality of irrigation are needed.

The alluvial soils dummy is negative but statistically insignificant in both the 1959/60–

Table 4. Regressions of the Total Value of Crop Output on Selected Independent Variables, Rice Region

Independent Variable	1959/60–1961/62 Average				1967/68–1968/69 Average			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop area	0.751	0.769	0.798	0.716	0.821	0.834	0.803	0.768
	(8.175)	(9.181)	(9.621)	(7.069)	(7.249)	(8.637)	(7.662)	(7.053)
Irrigated area	−0.009	−0.004	−0.004	−0.004	0.014	0.007	0.010	0.012
	(−0.591)	(−0.295)	(−0.289)	(−0.298)	(0.685)	(0.429)	(0.619)	(0.726)
Fertilizer	0.129	0.069	0.051	0.067	0.117	0.135	0.148	0.156
	(5.998)	(2.823)	(2.008)	(2.418)	(3.296)	(3.680)	(3.685)	(3.848)
Tractors	−0.017	−0.005	−0.016	−0.003	0.041	−0.009	−0.004	0.002
	(−0.622)	(−0.187)	(−0.623)	(−0.096)	(1.267)	(−0.328)	(−0.132)	(0.081)
Labor	−0.026	0.083	0.047	−0.038	−0.136	−0.017	0.013	−0.071
	(−0.279)	(0.928)	(0.524)	(−0.353)	(−1.022)	(−0.160)	(0.118)	(−0.523)
Total rainfall		0.219	0.229	0.205		0.380	0.390	0.410
		(2.173)	(2.323)	(2.068)		(2.688)	(2.739)	(2.868)
Red-coastal alluvial soil		0.172	0.151	0.153		0.126	0.112	0.120
		(2.295)	(2.045)	(2.088)		(1.458)	(1.265)	(1.351)
Alluvial soils		−0.108	−0.101	−0.082		−0.133	−0.144	−0.121
		(−1.611)	(−1.538)	(−1.244)		(−1.816)	(−1.928)	(−1.565)
Work animals				0.156				0.128
				(1.389)				(1.164)
Surfaced roads		0.147	0.150	0.133		0.210	0.212	0.208
		(2.478)	(2.591)	(2.261)		(3.708)	(3.723)	(3.663)
Pumpsets			0.041	0.045			−0.018	−0.011
			(2.008)	(2.202)			(−0.783)	(−0.475)
Constant	2.169	−1.119	−1.151	−0.918	2.140	−2.626	−2.748	−3.106
$\bar{R}^2$	0.842	0.888	0.894	0.895	0.800	0.882	0.881	0.882

Note: *t*-values are in parentheses.

1961/62 and 1967/68–1968/69 periods in all but equations (6) and (7). The coefficients of the red-coastal alluvial soil are positive and significant in the 1959/60–1961/62 period but are positive and insignificant in the 1967/68–1968/69 period.

Surfaced roads appear to be important in explaining productivity differences among districts, and their importance increases in the latter period. The absence of roads in a heavy rainfall area such as the rice region has the effect of raising input prices paid by farmers and lowering output prices received by them due to higher transportation costs. As Easter and Singh point out, these price relationships are unfavorable to the use of modern inputs such as fertilizer, and they retard tubewell development, especially where electricity is not available and diesel fuel has to be used.

Fertilizer use makes a significant contribution to production. The availability and price of fertilizer and their relationship to infrastructural development (roads and marketing facilities) appear to be important considerations in increasing production in this region.

During the study periods there is little technological change, as measured by the adoption of high-yielding varieties, in the rice region, in contrast with what occurs in the wheat region. Data on the adoption of new varieties of rice are given in table 5. Of the states under study, Andhra Pradesh has the highest adoption rate in 1968/69, with 16.6% of the paddy area planted to high-yielding varieties. Accordingly, temporal changes in the coefficients of the production functions for rice as large as in those for wheat are not observed. Also, the change in the mean value of crop output per

Table 5. Percentage of Paddy Area Planted to High-Yielding Varieties by States, 1966–67 to 1968–69

State	1966–67	1967–68	1968–69
		–%–	
Andhra Pradesh	8.3	10.3	16.6
Bihar	1.5	4.9	5.0
Orissa	1.1	2.8	3.4
Uttar Pradesh	1.6	3.4	7.3
West Bengal	0.6	3.4	4.0

Source: Abel.

district is relatively small over the study period, from Rs. 200.845 million to Rs. 212.463 million.

A Chow test is used to test if regressions (3) and (7) and regressions (4) and (8), respectively, are different. The calculated values of the F-statistic are 1.88 for the comparison of regressions (3) and (7) and 1.57 for the comparison of regressions (4) and (8). The hypothesis that the regressions are not different cannot be rejected at the 5% level of significance for each comparison.

The calculated marginal products corresponding to the regressions in table 4 are presented in table 6. The marginal products for crop area, irrigated area, and tractors seem to increase slightly, those for surfaced roads increase substantially, the marginal products for fertilizer decline substantially, and those for labor decrease somewhat between 1959/60–1961/62 and 1967/68–1968/69. Over this same period the mean values of the variables per district go from 435,164 to 458,670 hectares for cropped area, from 42,951 to 60,951 hectares for irrigated area, from 374 to 2,014 metric tons for fertilizer, from 26 to 75 for tractors, from 540,365 to 534,988 for laborers, and from 124 to 194 for pumps.

The results are basically consistent with a slow rate of technical change and a decline in the price of fertilizer relative to rice. The ratio of the wholesale price of rice to the wholesale price of urea goes from 0.75 to 1.24, or an increase of 65% during the period being studied.

Conclusions

Factors other than traditional inputs unadjusted for quality differences are important in explaining agricultural productivity differences within and between the wheat and rice regions of India. Identification of these additional factors is important for sharpening the focus of planning and development efforts and increasing the productivity of development resources by directing them at easing the binding restraints to increased output.

For the wheat region in India, the introduction of new varieties, the expansion of irrigated area and improvement in the quality of irrigation through the use of tubewells, and increased supplies of fertilizer lead to substantial increases in production. In some parts of the wheat region, namely, the Gangetic Plain portions of central and eastern Uttar Pradesh, there is further opportunity to expand the area irrigated by tubewells (and canals). Further development of water resources in these areas will promote the adoption of the new wheat technology. In other areas, such as parts of Madhya Pradesh and Rajasthan, the opportunities for further irrigation are severely limited. The limitation of water will likely be an important restraint to adoption of new crop technologies requiring intensive use of water. Productivity increases in these areas will have to come from development and adoption of new technologies and production practices consistent with rainfed conditions.

In the eastern rice region somewhat different restraints appear to be binding during the period covered by this study. The development and adoption of improved varieties of rice are not widespread. Development efforts should be (and are being) directed toward the development of high-yielding varieties of rice adapted to local ecological conditions. Attention should also be paid to improving roads and related market structures in the eastern rice region. Development efforts along these lines would increase the profitability of new crop technology and the use of supporting in-

Table 6. Marginal Products, Rice Region

Independent Variable	1959/60–1961/62 Average				1967/68–1968/69 Average			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop area	0.342	0.351	0.363	0.326	0.380	0.386	0.372	0.356
Irrigated area	−0.041	−0.018	−0.018	−0.018	0.049	0.024	0.035	0.042
Fertilizer	63.66	34.05	25.17	33.06	12.34	14.24	15.62	16.46
Tractors	−110.14	−32.39	−103.66	−19.44	116.15	−25.50	−11.33	5.67
Labor	−0.009	0.031	0.017	−0.014	−0.054	−0.007	0.005	−0.028
Total rainfall		32.39	33.87	30.32		59.45	61.02	64.15
Pumpsets			66.41	72.89			−19.67	−12.02
Work animals				0.090				0.078
Surfaced roads		3,355.02	3,423.49	3,035.50		5,070.14	5,118.43	5,021.85

Note: see note in table 3.

puts and speed their adoption. In separate analyses (Easter 1974), it has also been shown that there are very high social and private returns from improving the quality of canal irrigation systems. However, the government of India does not appear to give high priority to improving the quality of existing irrigation systems.

The usefulness of the foregoing analysis is illustrated by the work of Spriggs. Using data from table 4 together with other relevant information, he estimates benefit-cost ratios in the neighborhood of 8:1 for expanding the kilometers of surfaced roads in the eastern rice region, a handsome social rate of return, indeed. Furthermore, the assumptions used by Spriggs are purposely designed to yield conservative estimates of the calculated benefit-cost ratios. Similar analyses could be carried out with respect to other investment possibilities in each of the regions to determine the socially most productive investments.

In this approach we have tried to disaggregate the analysis of agricultural productivity growth using the district as the basic unit of observation. As in earlier work, we can combine these districts into relatively homogenous subregions with respect to the restraints to increasing output, although there still may exist much variation among the important constraints and the quality of factors within each subregion. Further disaggregation may be highly desirable to account for the remaining variability in productivity within regions and to identify better the binding constraints. The work by Herdt, De Datta, and Neely represents efforts in this direction and should provide valuable information for better directing development resources toward removing the overriding barriers to increasing agricultural productivity and improving the distribution of these productivity gains.

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Appendix

Definition of Variables

Crop area: annual gross cultivated area (hectares) in each district (India, Government of 1970, 1971c).

Fertilizer: total metric tons of N, P, and K used annually in each district. This measure is an unweighted sum of the three nutrients (Donde and Brown).

Irrigation: annual gross irrigated area (hectares) in each district (India, Government of 1970, 1971c).

Irrigation index: calculated measure of gross irrigated area in each district in which area irrigated by tubewells receives a weight of 1.5 and all other irrigated area receives a weight of 1.0.

Labor: number of male and female agricultural workers in each district, including both cultivators and laborers. Data are available for the census years 1961 and 1971 and are derived by interpolation and extrapolation for other years (India, Government of 1961b, 1971b). This is a measure of the stock of agricultural labor available in each district but not of the labor actually employed in crop production.

Monthly rainfall: average rainfall for specified months, 1901–50, in millimeters, for each district (India, Government of 1962b).

Pumpsets: number of pumps including electric and oil engines used for irrigation. Data are available for only 1956, 1961, and 1966 (India, Government of 1956, 1961c, 1966).

Soils (rice region): three soil types are used—recent alluvial, red with coastal or deltic alluvium, and red. Districts are classified as described for soils in the wheat region. Dummy variables are used for recent alluvial and red with coastal or deltic alluvium (Rajan).

Soils (wheat region): three soil types are used—black, alluvial, and red. In general, a district is classified as belonging to a particular soil type if 50% or more of the land is accounted for by that soil type. Dummy variables are used for black and alluvial soils (Rajan).

Surfaced roads: kilometers of hard surfaced roads per square kilometer of land in each district. Data are available for 1968 for all states except West Bengal, where 1960 data has to be used (India, Government of 1961a, 1962a, 1969, 1969–70; West Bengal, Government of).

Total rainfall: average annual rainfall, 1901–50, in millimeters, for each district (India, Government of 1962b).

Tractors: number of tractors in each district. Data are available for 1956, 1961, and 1966 and are derived by interpolation and extrapolation for other years (India, Government of 1956, 1961c, 1966).

Tubewells: ratio of net crop area irrigated by tubewells to net crop area. Data are available for 1961 and 1968 (Punjab, Government of; Haryana, Government of; Rajasthan, Government of; Directorates of Agriculture, Madhya Pradesh and Uttar Pradesh). This variable as well as the irrigation index are used to measure differences in quality of irrigation.

Value of total crop output: annual total value of crop output in each district in terms of 1959/60–1961/62 average prices, in thousand rupees (India, Government of 1971a, c; 1970).

Work animals: number of work cattle and bullocks in each district. Data are available for 1956, 1961, and 1966 and are derived by interpolation and extrapolation for other years (India, Government of 1956, 1961c, 1966).

Labor Force Participation in Southern Rural Labor Markets

Loren C. Scott, Lewis H. Smith, and Brian Rungeling

Despite the extensive study of labor force participation rates, factors influencing the labor force status of rural workers have received relatively little attention. Employing primary data from interviews conducted in four southern rural counties, this study investigates the major determinants of labor force participation among six subgroups in the sample. Evidence from probit analysis indicates the critical role of health in the participation decision of virtually all subgroups. The expected wage is found to significantly influence the participation decision of secondary, but not primary, workers. Manpower policies involving day-care centers, discrimination, and job training are also investigated.

Key words: health, labor force participation, rural, South.

During the past decade a number of economists have studied the factors that determine whether or not a person participates in the labor force. The dependent variable in most of their models has been the labor force participation rate (LFPR) of some subgroup within the population (Barth; Bowen and Finegan; Cain 1969; Strand and Dernburg 1964, 1966; Wachter). These investigations sought to explain either variations in LFPR's across standard metropolitan statistical areas (in the cross-section studies) or variations in LFPR's of the national population over time. A smaller number of models have been based on observations across individuals, where the objective was to isolate those factors determining the labor force status (LFS) of the group involved. The dependent variable in these studies was dichotomous, taking on a value of one if the person was in the labor force and zero otherwise (Berkowitz and Johnson, Fleisher, Spencer, Gramm).

A common characteristic of these studies is their concentration either on urban populations or the total national population—the latter being 60% to 70% urban according to Marshall. None deals specifically with the participation decision of rural residents. The purpose of this paper is to complement these other studies by analyzing factors that determine the labor force status of the rural population and various subgroups within the population.

A comparison of LFPR's of rural residents versus the national population suggests that this is a fruitful area of inquiry. Table 1 illustrates these comparative rates across various race-sex categories. LFPR's across both race and sex lines are significantly lower for rural areas than for the national population. The figures in table 1 actually mask the magnitude of the differences because the rural data include only household heads and not all persons twenty years old and older.

A number of explanations for this rural-national variance are possible. It may be that the significant determinants of labor force participation differ between the two areas. Perhaps custom, tradition, and mores are sufficiently different in rural areas so that the marginal effects of the various determinants on the participation decision are stronger (or weaker). It is more likely, however, that factors detrimental to labor force participation —health problems, a population with a high dependency ratio, and similar factors—are quantitatively greater in rural areas. By estimating a model of rural labor force participation, these issues may be addressed, and manpower policies appropriate for rural areas can be suggested.

Loren C. Scott is an associate professor of economics, Louisiana State University; and Lewis H. Smith and Brian Rungeling are associate professors of economics, University of Mississippi.

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Table 1. Labor Force Participation Rates by Race and Sex, 1973

Subgroup	Labor Force Participation Rate	
	Rural[a]	National[b]
Men		
Anglos	69.2	81.6
Blacks	66.7	78.2
Chicanos	70.1	85.9
Women		
Anglos	32.6	43.5
Blacks	38.5	51.6
Chicanos	22.2	41.1

[a] LFPR's for rural residents come from our sample data and are for household heads only. National population rates are for women or men twenty years of age and older.
[b] Source: U.S. Dep. Labor, table A-7, p. 214.

Data Source

Data used in this paper come from a household survey conducted in four southern rural counties in 1973. The counties were chosen from a sample of counties that have a majority of its population classified as rural, whose borders are more than 50 miles from a metropolitan area, and are within the Bureau of Census definition of the South. To be representative of the South, the counties ideally have a larger rural population and an economy historically dominated by agriculture. Four counties were selected in an effort to capture the rather wide range of socioeconomic characteristics of southern rural counties. The counties selected include a county in Texas located near the Mexico border whose population is almost totally Chicano, a Georgia county whose population is 75% Anglo; a Louisiana parish with a 60%-40% Anglo-Black population, and a Mississippi Delta county with a 40%-60% Anglo-Black racial mix. The Mississippi, Louisiana, and Texas counties have work forces that are heavily oriented toward agriculture. There is a large migrant worker contingent whose permanent base is in the Texas county. The Georgia county is the most industrialized of the four.[1]

Data were collected in the counties by personal interview from a random sample of 3,357 households. The sample was selected from a list of addresses with location of all dwelling units updated from 1970 census records (U.S. Dep. Commerce 1973), by aerial photographs (U.S. Soil Conservation Service), and data supplied by local authorities (Dep. Highways Office). A simple random sample was drawn from the list of households.

Data were collected and broadly classified into several groups: (*a*) demographic information; (*b*) labor force information, both historical and current; (*c*) income and earnings and physical asset data; (*d*) welfare program information; and (*e*) behavioral and attitudinal information. The sample of 3,357 households provides a wide variety of labor market data on 7,481 individuals over sixteen years of age.

The Labor Force Status Model

In an attempt to isolate those factors that determine whether or not a rural resident participates in the labor force, a labor force status model is developed and estimated for seven subgroups of the rural population. These seven subgroups can be separated into two classifications—primary workers and secondary workers. Primary workers include household heads inclusively, prime-age males (ages 25 to 54), and female household heads. Four subsets of secondary workers are examined—elderly males (ages 65 and up), married women, teenage males, and teenage females.[2] These particular secondary workers are chosen because their national LFPR's have been experiencing rather dramatic changes since the turn of the century.

The basic LFS model is

$$(1)\quad LFS = f(WED, HEALTH, OINCOME, EWAGE),$$

where *LFS* is a dichotomous dependent variable taking on a value of one if the individual is participating in the labor market and zero otherwise. Because *LFS* is dichotomous, the ordinary least squares (OLS) regression technique for estimating equation (1) is inappropriate, since such a dependent variable would introduce heteroskedasticity into the error term. As a result, the variances of the coefficients in an OLS equation would be biased in a direction that may lead to rejection of some coefficients that may, in fact, be statistically

[1] Unpublished 1974 data from the Bureau of Economic Analysis show that total labor and proprietor's income in the farm sector in the Mississippi, Texas, Louisiana, and Georgia counties were (in millions) $40.9, $21.7, $14.1, and $7.9, respectively (U.S. Dep. Commerce 1970–74).

[2] By definition, the married women and teenage subgroups do not contain any household heads.

significant. Also, the resulting estimate of the conditional probability of participation is not constrained to fall within the zero to one range (see Kmenta, pp. 425–28). Several methods of data transformation are available for correcting this problem. The probit technique developed by Finney is chosen to estimate equation (1).

Equation (1) suggests that the decision to participate in the labor force is influenced by the marital status of the individual (*WED* = 1 if married; 0 otherwise). Those persons who are married have greater financial responsibilities than those who are single; thus, the former are more likely to be in the labor force than the latter (see Bowen and Finegan, p. 23).

Mushkin has shown that health problems are detrimental to labor force participation, and investigations based on urban and national samples have supported this hypothesis empirically (Davis; Luft; Morgan, David, and Brazer). Individuals in the rural sample were asked a series of questions relating to health, including the nature of their health problem, whether or not the individual was under a doctor's care, the time elapsed since the health problem was first discovered, and the anticipated duration of the problem. The individual was asked if he believed the problem impaired his ability to work. The total acquired information was analyzed to determine if an individual had a health problem that could affect his work performance. *HEALTH* in equation (1) is a dummy variable with a value of one for those who were determined to have a work-inhibiting health problem and zero for all others.

Work-leisure indifference curve analysis suggests that the receipt of nonlabor income should cause an individual to choose more leisure time (assuming leisure time is a normal good) and to work less. To control for differences in the amount of nonlabor income received across individuals, *OINCOME*, defined as the difference between total household income and earnings of individual, is included in equation (1).[3] Although the components that other income should include as well as the nature and strength of its impact on the LFS of different groups has not been unequivocally established, the need for some measure of other income in the LFS analysis is generally recognized (see, for example, Berkowitz and Johnson; Bowen and Finegan; Luft; Morgan, David, and Brazer; Wachter). Recent findings by Watts et al. indicating that the disincentives associated with outside income are greatest for low income families are of particular relevance to this study.

Two additional variables are employed in the LFS equations for women. Since women have traditionally assumed responsibility for the care of children in the home, the presence of children should have a negative influence on the woman's decision to enter the labor force. The presence of children in the home in effect raises the woman's "at-home wage" and induces her to remain out of the labor force. Hence, the variable *CHILD* (1 = has responsibility for children at home; 0 otherwise) is added to the LFS equations involving women. Cain (1971) has shown the presence of child-care facilities nearby can reduce some of the costs of child care and induce some women to enter the labor force at the margin. Thus, *CARE* (1 = child-care facilities available nearby; 0 otherwise) is also added to these equations. A modification is also required in the LFS equations for teenagers to allow for an obvious and important alternative to work for them—school attendance. *SCHOOL* (1 = presently attends school; 0 otherwise) is used to capture this effect.

Finally, *EWAGE* in equation (1) is the expected wage rate per hour of the individual if employed. Following Bowen and Finegan, one would think that the greater the *EWAGE*, *ceteris paribus*, the greater the individual's inducement to substitute an incremental hour in the labor market for an incremental hour at home. A difficult practical problem is how to measure *EWAGE*. Actual wage data are available only for those persons presently employed. In the LFS model, an expected wage must be inserted for all three classifications of individuals: those who are working (*E*), those who are actively seeking work (*U*), and those who are out of the labor force (*O*). One approach might be to use the actual wage of the *E*'s for their *EWAGE* and then employ an average wage of the *E*'s as estimates of *EWAGE* for those classified as *U* or *O*. However, not only does the mixture of an actual wage and an expected wage in the empirical estimation present theoretically difficult prob-

[3] *OINCOME* includes primarily government transfer payments and earnings of other household members. A very small component comes from private transfers. No in-kind income is included, nor are food stamps. Although the food stamp bonus represents income, for a significant percentage of the sample households the purchase requirement prevents the incorporation into the *OINCOME* variable in any meaningful way; that is, it represents a decline in actual food prices subject to a constraint and is unlikely to be recognized as an increase in income.

lems but imprecise results also arise because the only persons with values below the mean wage are those currently employed, an unlikely depiction of reality.

Rather than mix actual and expected wages in the model, a methodological approach previously taken by Boskin is chosen that uses an expected wage across all individuals in the sample. The following model is derived in order to determine a person's *EWAGE:*

(2) $EWAGE = f(SEX, ANGLO, BLACK, AGE, AGESQ, ED, TRAIN, GA, MISS, LA)$.

A person's expected wage is dependent on several factors in the labor market. Marginal productivity theory suggests that those persons with more education, formal training, and job experience, i.e., with greater endowments of human capital, are expected to earn higher wage rates. Hence, *ED* is entered as a continuous variable measuring years of education attained via elementary school, secondary school, and college. *TRAIN* is a dummy variable taking on a value of one if the person participated in a formal vocational or on-the-job training program, such as offered through Concentrated Employment Programs, Work Incentive Programs, and Manpower Development and Training Act programs, and zero otherwise. Serving as proxies for amount of on-the-job work experience are *AGE* and *AGESQ*—the individual's age (in continuous form) and age squared.

Equation (2) contains three variables designed to capture differentials in expected hourly wage rates across sex and race lines. *SEX* is a dichotomous variable having a value of one for men and zero for women. The rather voluminous literature on sex wage differentials indicates that *SEX* should be positively associated with *EWAGE* either because women suffer from wage discrimination (Ferber and Lowry) or their occupational choices, considered alongside household duties, lead them into lower paying jobs vis-à-vis men (Gwartney and Stroup). Racial wage differentials are measured by using *ANGLO* (1 = anglo; 0 = nonanglo) and *BLACK* (1 = black; 0 = nonblack). The omitted category is Chicano; hence, the coefficients on *ANGLO* and *BLACK* measure anglo and black wage rates relative to those of Chicanos. While it is not clear what sign should be expected on the *BLACK* coefficient, the coefficient on *ANGLO* should be positive, reflecting racial discrimination and/or differences in the quality and quantity of education and training received by nonwhites vis-à-vis whites.

Differences in the economic health and general job availability between the four counties in the sample may influence the general wage rates received by residents of one county when compared with another. To hold constant these variances across counties, *GA* (1 = resides in the Georgia county; 0 otherwise), *MISS* (1 = resides in the Mississippi county; 0 otherwise), and *LA* (1 = resides in the Louisiana parish; 0 otherwise) are inserted in equation (2). Thus, the coefficients on each of the county variables measure how wage rates in that county compare with the Texas county, which is the one omitted.

Equation (2) is estimated using as observations the rural residents who are employed. Once estimated, both employed and nonemployed persons' characteristics are inserted into equation (2), and the individual values for *EWAGE* are established for use in the LFS equation. To the extent that the independent variables in equation (2) significantly affect *EWAGE,* they also indirectly affect the LFS decision in those subgroup LFS equations where *EWAGE* is significant.

Empirical Results

The EWAGE Equation

In table 2 the results of estimating equation (2) are presented. All of the signs are in the direction suggested by a priori reasoning. Each of the human capital embodiment variables—labor market experience (via *AGE, AGESQ*), education, and formal training—is significantly related to *EWAGE*. In addition, the results indicate that men earn significantly more per hour than women after adjusting for human capital differences. There is the problem of determining whether the lower wages earned by women are the result of employer discrimination or occupational preferences of women. Another study using a national sample suggests that national male-female wage differentials are more a function of female occupational preferences than sex discrimination (Gwartney and Stroup). It is argued that because women have, in addition to possible market-work responsibilities, responsibility for housework and child care, they choose

Table 2. Regression Coefficients for the *EWAGE* Equation

Independent Variables	Regression Coefficient (*t*-values)
Constant	−2.94
SEX	1.05
	(20.15)
ANGLO	0.26
	(1.51)
BLACK	−0.34
	(1.91)
AGE	0.14
	(13.25)
AGESQ	−0.001
	(11.11)
ED	0.18
	(25.61)
TRAIN	0.21
	(6.96)
GA	0.27
	(1.52)
MISS	0.18
	(1.00)
LA	0.25
	(1.40)
R^2	0.36
F	153.25
Sample size	2,765

those types of jobs that involve low pay but that have work schedules that allow them to also perform their housework. While the data do not permit a direct resolution of this issue, they do reveal substantial occupational segregation on the basis of sex, as well as other evidence of wage discrimination.[4]

The issue of racial wage differentials in these southern rural counties is less clear. The *t*-value on neither race variable is exceptionally high. However, the *t*-value on *BLACK* (1.91) is sufficiently large so that a notable racial wage differential—adverse to blacks—is implied. Because human capital differences were held constant, there is a strong presumption that the racial wage differential is due to discrimination. One might argue that the education variable is not adjusted for differences in the quality of education received across race lines, which at least one study found to be a significant factor in the black-white differential (Welch). However, the educational quality differential may also be a product of past discriminatory behavior. Thus, to the extent that *EWAGE* significantly influences the LFS decision, wage discrimination toward blacks adversely affects their labor force participation in southern rural markets.

Finally, it is pointed out above that the four counties in the sample have varying industrial mixes. Once racial, sex, and human capital differences have been controlled, the statistics for *GA*, *MISS*, and *LA* suggest that these proxies for variations in industrial mix, the level of economic activity, and job availability between counties have no significant influence in *EWAGE*.

The LFS Equation

The ultimate objective of this research is to discover those factors that determine whether or not a rural resident will participate in the labor force. Table 3 contains selected characteristics of the sample subgroups, and the culmination of this inquiry is presented in table 4.

Perhaps the most consistent phenomenon in

[4] When differences in productivity factors are held constant, the average male wage remains over 40% higher than the female wage. For a more complete discussion of sex discrimination, see Smith, Smith, and Rungeling.

Table 3. Characteristics of Subgroups

Characteristics	All Household Heads	Men (25–54)	Female Household Heads	Males 65+	Married Women	Teenage Males (16–19)	Teenage Women (16–19)
Mean *EWAGE* ($)	3.38	3.78	2.54	3.53	1.87	2.00	1.03
Percentage with health problems (%)	32	15	42	56	23	4	3
Percentage married (%)	68	95	0	80	100	2	14
Mean age	52	38	56	73	45	17	17
Mean educational attainment	8.0	9.5	9.1	5.2	9.0	10.3	10.6
Percentage white (%)	46	49	46	46	49	30	29
Percentage with child responsibility (%)	—	—	17	—	30	—	9
Percentage located near day-care center (%)	—	—	11	—	16	—	5
Percentage in school (%)	—	—	—	—	—	73	66
Sample size	3,336	1,252	890	580	2,178	470	466

Table 4. Probit Regression Results: Labor Force Status Equations (*t*-values)

Independent Variables	Primary Workers				Secondary Workers		
	Household Heads	Men (25–54)	Female Household Heads	Males 65+	Married Women	Teenage Men (16–19)	Teenage Women (16–19)
Constant	−0.07	2.16	−0.74	−1.43	−1.85	−1.00	−1.43
EWAGE	0.11	0.01	0.19	0.21	0.74	1.16	0.92
	(4.72)	(0.13)	(3.73)	(3.23)	(12.31)	(2.77)	(1.97)
WED	0.91	0.19		0.17		−0.13	−0.001
	(15.95)	(0.62)		(0.93)		(−0.89)	(−0.01)
HEALTH	−1.50	−2.19	−1.55	−0.78	−1.18	−1.65	−0.08
	(−27.38)	(−15.31)	(−8.94)	(−5.46)	(−7.04)	(−3.19)	(−0.14)
OINCOME	−0.007	−0.005	0.007	−0.005	−0.03	0.003	0.02
	(−9.30)	(−2.88)	(2.12)	(−2.59)	(−3.57)	(0.03)	(0.51)
SCHOOL						−15.33	−13.07
						(−20.12)	(−0.01)
CHILD			0.43		−0.34		−1.61
			(2.54)		(−3.98)		(−2.70)
CARE			0.73		0.33		0.61
			(3.49)		(3.43)		(1.24)
Sample size	3,336	1,252	890	580	2,178	470	466
Mean LFPR	0.59	0.92	0.34	0.15	0.29	0.20	0.11

table 4 is the importance of health in the labor force participation decision of the rural population. The only equation in which health is shown to have no significant affect on the desire to work is the teenage women equation. Table 3 shows that only 3% of this subgroup indicated having health problems severe enough to prevent holding a job. The importance of health in explaining labor force participation is evident in the findings of investigations of urban and national LFS decisions (Davis; Luft; Morgan, David, and Brazer). Interpretation of the results requires qualification. Although a priori reasoning, casual observation, and intuitive feeling strongly suggest that the labor force status of the individual is affected by his health, researchers have noted correctly that there is a substantial amount of interaction between such factors as health and education and labor force participation (Bowen and Finegan, Davis, Luft). Therefore, such variables could serve as surrogates for a measure of health. Berkowitz and Johnson, however, demonstrated that for their sample neither education, other income, nor marital status is a proxy for health and that the omission of measures of health reduces the explanatory power of analytical labor force participation models.

It is possible in the present study that the health variable may in part reflect the narrower industrial structure in rural areas. Unlike metropolitan areas, the economy of the rural South contains few jobs that are accessible to persons with severe health problems or physical handicaps. It is possible that a significant number of rural persons outside the labor force due to health problems would in fact be employable in urban areas.[5]

EWAGE has the expected positive influence on the LFS decision and is statistically significant in all the equations except that for prime-age males. As one might predict, the coefficient on *EWAGE* is larger for secondary workers than for primary workers. Secondary workers typically have greater freedom in choosing between participation and nonparticipation in the labor force. Married women, for example, with their presumed responsibility for child care and housework, are more likely to be drawn into the labor force by higher wages. Prime-age males, on the other hand, whose chief responsibility is that of breadwinner, have less freedom of choice in the LFS decision and are more prone to work no matter what the *EWAGE*.

Income from sources other than the job has

[5] One test of this hypothesis might be to estimate equations (1) and (2) for a comparable group of urbanites. If the coefficient on the health variable indicates a significantly larger negative impact on the LFS decision in the rural equation than in the urban one, this constitutes evidence in support of the hypothesis. Unfortunately, no urban data were collected in this study, and the models used in other investigation are not sufficiently comparable with ours to make direct comparisons.

the expected negative relationship with the LFS decision of all adult subgroups in the sample. While there is a question of direction of causality, work-leisure indifference curve analysis argues that increases in positive income transfers—such as welfare payments, social security—should reduce the labor force participation of adult recipients. However, given that *OINCOME* is entered in thousands of dollars, the magnitude of its coefficient suggests that the marginal influence of these payments on the LFS decision is probably rather minor, particularly when compared with *HEALTH* and *EWAGE*. As a result it can be anticipated that increased labor force participation by secondary workers would not have a noticeable effect on the labor force status of primary workers.

Responsibility for children in the home has an expected detrimental effect on the participation decision of married women and teenage women. However, responsibility for children appears to encourage female household heads to enter the work force. Possibly, this is because these latter women are unmarried, and the *CHILD* variable has the same influence on their LFS decision as the expected influence of *WED* on the male LFS decision; that is, the increased financial responsibilities imposed by the children exert a pressure on female household heads to enter the labor force. From a manpower policy standpoint, it is interesting to find that the provision of nearby day-care centers draws adult women into the labor force, with the influence being particularly strong for female household heads.

Finally, it is no startling revelation to find that the LFS decision of rural male teenagers is strongly influenced by whether or not they are in school. Thus, manpower policies designed to improve the educational attainment of this group result in conflicting effects on the teenage male LFPR. On the one hand, more education tends to directly draw him out of the labor force. However, the higher educational level improves the teenager's *EWAGE*, which tends to draw him into the labor force.

Summary and Implications

That the incidence of poverty is greater in rural areas than in urban areas is well documented by Marshall.[6] One aspect of this rural-urban poverty differential is the lower labor force participation rates of rural residents. By examining the determinants of labor force participation rates among this segment of the population, we have been able to isolate a number of areas where manpower policies might be fruitfully applied to improve this dilemma.

For example, since *EWAGE* has a significant and positive impact on the LFS decision of six of the subgroups examined, manpower policies that might raise *EWAGE* should indirectly increase the LFPR of the rural population. For example, these results show that the *EWAGE* is positively associated with educational attainment and participation in formal training programs. Thus, manpower policies that reduce drop-out rates, increase the quality of education, and/or allow greater enrollment in government-sponsored training programs should have the beneficial by-product of improving rural LFPR's, particularly for secondary workers. This finding could hold significant implications for anti-poverty efforts in the rural South. Many households surveyed in this study were above the poverty level only by virtue of the earnings of secondary workers. In addition, many more would have been lifted beyond the poverty threshold if there had been a secondary worker in the household.

Further, to the extent that sex-wage differentials are due to sex discrimination (rather than occupational preference on the part of women), manpower policies designed to reduce this phenomenon will indirectly lead to greater rural LFPR's. This evidence also suggests a "borderline" relationship between *RACE* and *EWAGE*. Consequently, it is quite likely that efforts to improve the quality of education received by blacks and to remove any overt racial discrimination towards them will not only improve the *EWAGE* for blacks but may also increase their LFPR.

That poor health is a major factor inhibiting labor force participation in the rural South is quite evident from the data. Of the sixteen- to sixty-five-year olds with health problems in this sample, only 25% are participating in the labor force. The most numerous type of health problems are those classified as cardiovascular, followed in order of incidence by arthritis, mental and nervous disorders, and vision and hearing problems, The percentage of persons

[6] In 1970, in the South, the median income of urban residents was $3,814, while the comparable figures for rural farm workers was $2,700 and for rural nonfarm workers it was $3,130 (Marshall, p. 77).

with these problems who are unable to participate in the labor force are 19.8%, 28.0%, 11.9%, and 30.0%, respectively.

Perhaps a large part of this strong impact of health problems on labor force participation results from the disadvantages faced by rural areas vis-à-vis other areas in the provision of health care. While the number of hospital beds per 1,000 population was 7.4 nationally in 1971, the figure ranged from 1.2 to 5.1 in the counties in this sample. Similarly, the number of persons per doctor ranged from three-and-one-half to over seven times the national average for these rural counties (see Hague; U.S. Dep. Health, Education, and Welfare). Although there is little data to support the contention, there is a strong presumption that the quality of health services in rural areas is not on a par with those in urban areas. Since health services are thought to be income elastic, and because incomes are lower in rural areas than in urban areas, it is most unlikely that market forces alone can be relied on to remove the disparity. If improvement of LFPR's in rural areas is to be a national manpower objective, these findings suggest that additional public funds for health services and preventive health care in rural areas may be beneficial. It appears to be true that, although nonparticipation by certain groups (especially prime-age males) is not exclusively a medical problem, increased access to health care should increase labor force participation (Bowen and Finegan). Furthermore, health services or preventive health care surely provide social benefits greater than the output loss attributed to the afflicted.

Based on the evidence from this sample, we have suggested manpower policies that should increase the number of individuals desiring work in rural areas. However, to effectively combat poverty in these regions, policies designed to raise rural LFPR's must be combined with programs that will also create jobs. Without the latter, the former will merely create additional frustration and social unrest.

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Public Service Employment and Rural America

Philip L. Martin

Public service employment programs are manpower instruments that provide income and transitional employment in times of high unemployment. Despite annual expenditures of nearly $1 billion since 1971, little attention has been directed toward the rural-urban distribution of public employment funds. After establishing alternative allocation formulae, actual allocations are compared with hypothetical allocations for public employment programs since 1971. The results indicate that rural areas did not obtain public employment funds in proportion to their shares of total unemployment. Reasons for the observed pattern of allocations are explored, and alternative allocating criteria to increase funds available to rural areas are discussed.

Key words: manpower programs, public employment programs, rural areas, unemployment.

In 1971, the nation initiated a national public service employment (PSE) program to help mitigate the individual hardships attending severe unemployment and to enable state and local governments to supply needed public services. First under the Emergency Employment Act (EEA) of 1971 and later under titles II and VI of the Comprehensive Employment and Training Act (CETA) of 1973, federal outlays for this countercyclical labor market instrument have averaged nearly $1 billion annually. At the estimated $8,000 cost per man-year of public employment, the $1 billion outlay provided only 125,000 jobs for the 5 million unemployed in 1974. Thus, to distribute the limited funds available for combatting unemployment via public service employment, allocation formulae had to be devised for disbursing available funds among states and local areas.

This study examines the rural-urban distribution of funds for the creation of public service employment programs since 1971. Under the EEA, county census data (U.S. Dep. Commerce) are aggregated to construct indicators of need for a ten-way county class taxonomy in which all counties or county attributions are arrayed along a rural-urban spectrum. Ratios derived by comparing county class shares of PSE monies with various indicators of county class need shares are constructed to assess the equity of the actual allocations process. Under the CETA, the same funds-to-needs share ratios are derived for states and prime sponsoring agents within states. Although none of the alternate need indicators are a perfect measure of relative area funding priorities, the indicators used should produce ratios of funding shares to need shares that are close to but not uniformly one.

The following section epitomizes the salient provisions of the EEA and the CETA. After describing fund allocation procedures and program administrative requirements, actual fund distribution patterns under the EEA and the CETA are reviewed. The sources of the observed rural bias are hypothesized to emanate from (*a*) the allocation criteria utilized, especially from reliance on local unemployment estimates; (*b*) administrative requirements that limit outlays for ancillary equipment; and (*c*) rural-urban differences in program outcomes, i.e., the ability of the program to reduce unemployment. Because federal outlays for programs that explicitly seek to reduce unemployment dominate any state and local efforts, modifications of prevailing allocation formulae that could redress appar-

Philip L. Martin is an assistant professor of agricultural economics, University of California, Davis, and an assistant agricultural economist in the Experiment Station and on the Giannini Foundation.

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ent discrimination against rural America are noted in the conclusion.

Public Service Employment Programs

Public service employment programs are manpower instruments designed to provide income, transitional employment, and needed public services, generally in times of high unemployment. First implemented on a national scale during the depression years, more recent PSE programs have been broadened to emphasize both countercyclical and work experience goals. The countercyclical goal of PSE's is essentially that of a work-conditioned unemployment insurance scheme. The work experience goal aims to simultaneously lower unemployment rates among specific target groups (Viet Nam veterans, minority unemployed persons, and low-income household heads) as it provides opportunities to train participants for entry into regular public employment, i.e., to make the transition from unemployed to regular employment status. Because need far exceeds total PSE appropriations and certain persons and/or areas are assumed to suffer most from unemployment, allocation formulae must be devised to distribute funds among competing target groups and/or areas.

Under the EEA and the CETA, allocations are made on the basis of a formula that gives equal weight to the volume and severity of area unemployment (the target groups specified in the enabling legislation act to determine local hiring priorities). Under the EEA, 75% of available funds are allocated to areas in proportion to their shares of national employment and their shares of national unemployment in excess of 4.5%. The remaining 25% of EEA funds are disbursed to areas whose unemployment rates for three consecutive months are in excess of 6%. An area's total EEA appropriation represents the sum of a volume and a severity of unemployment appropriation. Under the EEA, each state is guaranteed at least $1.5 million annually, and each program agent, who actually expends funds, is required to make a 10% contribution to the local appropriation.

The Comprehensive Employment and Training Act (CETA) emerged in late 1973 when political disagreement resulted in the expiration of the EEA. Of CETA's six titles, two appropriate funds for the creation of public service employment jobs.[1] Under title II, PSE funds are apportioned among areas experiencing unemployment rates in excess of 4.5% in accordance with area shares of unemployment, while title VI disburses funds according to a three-part formula that weights the area's share of total unemployment, the area's share of unemployment in excess of 4.5%, and the area's share of total unemployment in excess of 6.5% at one-half, one-fourth, and one-fourth, respectively. Under CETA, the local contribution requirements and state appropriation guarantees are dropped.

After determining a state's total allocation, PSE funds are apportioned to two types of areas within a state—direct prime sponsoring units of government, representing at least 75,000 persons under the EEA (100,000 under CETA), and smaller governmental units, which become subagents under each state's balance-of-state program. Prime sponsors or program agents, the larger cities and counties,[2] deal directly with federal allocating authorities (the regional manpower administrators), while state subagents seek funds through their state government. States are free to use any "equitable" formula for allocating funds among subagents in balance-of-state areas.

PSE Allocations Under the EEA and the CETA

In order to appraise PSE program allocations, the actual distribution must be compared with some alternative distribution. In this analysis, the share of PSE funds accruing to each county (EEA) or each state (CETA) is compared with the county or state's share of total unemployment or some other need indicator.[3]

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[1] Title I funds, the largest expenditure component under the CETA, support comprehensive manpower services in local areas. Although title I funds can be used to fund public service employment, the crossover is limited. In fiscal 1974, only 5% of title I funds were diverted from manpower services to public service employment. Titles III through V deal with special groups and policies. Title III directs the secretary of labor to operate manpower programs for youth, offenders, Indians, migrant farmworkers, and the underemployed. Title IV continues the Job Corps, and Title V establishes a national commission for manpower policy. Title IV was passed in December 1974 as the Emergency Jobs and Unemployment Assistance Act.

[2] In addition to states and the larger governmental units, Indian tribes and areas of "exceptional circumstance" may be designated as direct prime sponsors without regard to the population criterion.

[3] The allocation criteria suggested are those that were most prominent in congressional debate before the program's enactment, the unemployment share argument being concerned with

If the resulting ratio is one, the county or state receives a share of funds commensurate with its share of unemployment (or other indicator of need). Ratios greater than one indicate overallocations under the actual allocation formula, while ratios less than one indicate underallocations; i.e., had allocations been made according to unemployment shares, the area would have received more funds. Since evidence on shares of severe unemployment is not always available by county and state, one would expect a distribution of funds-to-unemployment share ratios close to but not uniformly one.

Under the EEA, allocations to counties for both unemployment shares and severities are tabulated according to a county taxonomy that arrays the 3,100 U.S. counties along a ten-way rural-urban spectrum (Hines, Brown, and Zimmer). For each county class and for the metropolitan-nonmetropolitan aggregates, the ratio of the share of funds to the 1970 unemployment share is calculated by county class (table 1). It is immediately apparent that nonmetropolitan areas did not receive funding shares commensurate with their shares of unemployment; indeed, the most rural counties fared worst. The fiscal year (FY)1973 distribution pattern, for which 1970 unemployment shares are a less reliable alternative allocator, shows the nonmetropolitan county classes improving their position but still receiving only 39% of the funds due them compared with their expected allocations under an unemployment shares criterion.[4]

While metropolitan counties, containing 72.8% of the unemployed, received nearly 90% of EEA funds in FY 1972 (88% in FY 1973), nonmetropolitan counties, with 27.2% of the unemployed, received only 10% of EEA funds (12% in FY 1973). Among nonmetropolitan counties, allocations range from 5% to 108% of a county class's unemployment-mandated share of funds, e.g., class 9 nonmetropolitan counties contained 1.11% of all unemployed persons but received only 0.06% of the EEA funds in FY 1973. In both FY 1972 and FY 1973, and under both the EEA and the CETA, the four county classes containing less than

restoring full employment and the population share proponents citing the lack of detailed unemployment data.

[4] The CETA data at the county level (Office of Economic Opportunity) are not strictly comparable with EEA allocations, since they include allocations for general manpower programs as well as public service employment.

Table 1. Population and Unemployment Distributions and EEA and CETA Funding Shares, Metropolitan and Nonmetropolitan Counties

County Class[a]	Unemployment Share, 1970[b]	Population Share, 1973[b]	Fund Share/ Unemployment Share[c] EEA, FY 72[d]	EEA, FY 73[d]	CETA, FY 74[d]	Fund Share/ Population Share[e] EEA, FY 72	EEA, FY 73	CETA, FY 74
	----%----							
Metropolitan (612)	72.80	72.55	1.25	1.23	1.15	1.25	1.23	1.16
Core (48)	32.60	28.26	1.48	1.36	1.20	1.70	1.57	1.39
Fringe (127)	9.95	12.67	0.64	0.59	0.54	0.51	0.47	0.43
Medium (258)	21.52	22.87	1.25	1.36	1.36	1.18	1.28	1.28
Lesser (179)	8.73	8.75	1.03	1.11	1.16	1.03	1.11	1.16
Nonmetropolitan (2485)	27.20	27.45	0.34	0.39	0.59	0.34	0.39	0.58
Urban adjacent (191)	6.76	6.96	0.93	1.08	0.84	0.91	1.05	0.81
Urban nonadjacent (137)	4.11	3.80	0.39	0.36	0.56	0.42	0.39	0.60
Less urban adjacent (564)	6.23	6.63	0.06	0.08	0.45	0.06	0.08	0.43
Less urban nonadjacent (721)	6.90	6.72	0.10	0.16	0.54	0.10	0.16	0.56
Thinly populated adjacent (246)	1.11	1.17	0.09	0.05	0.32	0.09	0.04	0.31
Thinly populated nonadjacent (626)	2.08	2.17	0.14	0.10	0.50	0.14	0.09	0.48

[a] The county classification is explained in Hines, Brown, and Zimmer. The number of counties in each class is in parentheses. The county classes are based on population density and proximity to SMSA's.
[b] Unemployment and population shares are derived from U.S. Dep. Commerce.
[c] The fund share/unemployment share ratio is calculated by dividing the share of total funds allocated to the respective county classes by the percentage of the nation's unemployed residing in the respective county classes in 1970.
[d] Fund shares are derived from *Federal Outlays* (Office of Economic Opportunity).
[e] The fund share/population share ratio is calculated by dividing the share of total funds allocated to the respective county classes by the percentage of the nation's population residing in the respective county classes in 1973.

20,000 urban residents received the least funds, irrespective of their contiguity to a standard metropolitan statistical area (SMSA). Among metropolitan counties, core central city areas were uniformly favored, with only the fringe counties adjacent to large SMSA's, i.e., the suburbs, not receiving their unemployment-mandated funding shares.

County level unemployment data are available only in census years; hence, comparison of 1970 unemployment shares with subsequent funds shares loses credibility over time. But the general picture of underallocations to rural areas that emerges from FY 1972 funds-to-unemployment share ratios seems to hold for subsequent years, since funds-to-population shares, which can be updated annually, are strikingly similar for the years when both unemployment and population data exist. In FY 1972, when nonmetropolitan counties contained exactly the same proportions of total unemployment and total population (27.2%), both the unemployment and population share analysis indicate that nonmetropolitan counties obtained only 34% of their justified allocation (table 1). Furthermore, the ratios computed from unemployment and population shares are remarkably similar over time, especially at the aggregate metropolitan-nonmetropolitan level, which suggests that relative unemployment shares remained stable over time.[5]

The EEA is designed to provide "transitional employment for unemployed and underemployed persons" (U.S. Congress, Senate). Because no precise definition of underemployment has emerged, no underemployment data enter the PSE allocation formula. The incidence of those factors cited as indicative of underemployment, viz, low-income household heads, involuntary part-time workers, and discouraged workers, is at least as frequent in rural as in urban America (Horne, Tweeten, and Holland; Marshall, p. 81). If, for example, funds are allocated on the basis of county class shares of low-income household heads, the apparent funding bias against rural areas would increase, with nonmetropolitan counties decreasing their share of total PSE funds from 34% of unemployment-indicated need to less than one-fourth of their "underemployment" deserved share of funds.

Under the CETA, county level PSE allocation data are unavailable for all states. Calculation of the same funds-to-unemployment share ratios at the state level produces a wide disparity in funds-to-need share ratios across states. Under both titles II and VI, those states that received less than 50% of the funds due them on an unemployment-share basis trace a U-shaped pattern from the upper Midwest across the South and along the southern coastal plain (figure 1). The source of this peculiar regional bias is not immediately obvious, although it should be noted that (*a*) the South experienced increased unemployment relatively late in the recession (Gellner, p. 15); (*b*) most of the states having low funds-to-unemployment share ratios are of intermediate population size, suggesting the possible existence of both small state and large state biases; and (*c*) some states and local areas may have failed to apply for PSE program funds.

After determining allocations to individual states, PSE funds are allocated to prime sponsors within each state, with each state acting as a prime sponsor for its rural or nonmetropolitan areas. Diversity among states precludes ready generalization, but apparently states that are underallocated funds in accordance with their shares of national unemployment in turn concentrate the PSE monies they received in their dominant urban areas. Unpublished data collected by the Regional Manpower Administration show that Kansas and Nebraska, for example, receiving only 10% and 40% of the PSE funds expected given their shares of total unemployment, in turn devote 25% and 96% of PSE funds received under title II to Kansas City and Omaha, respectively. Thus, even if states currently underallocated funds under existent PSE programs are to receive their unemployment-mandated funding shares, there is no assurance that these states would pass on such funds to their rural balance-of-state areas.

Sources of Rural Bias

The distribution of funds for the creation of public service employment programs under both the EEA and the CETA exhibits strong biases in favor of urban areas. Rural areas could fail to qualify for PSE funds if (*a*) their need for funds is underestimated; (*b*) the tim-

[5] Total unemployment rose some 22% (on an average annual basis) between 1970 and 1971 (U.S. Dep. Labor 1975). Since nonmetropolitan counties had higher unemployment rates in 1970, even if all the increase in unemployment between 1970 and 1971 was concentrated in metropolitan counties, a funds-to-unemployment share allocation would have provided more PSE funds to nonmetropolitan counties.

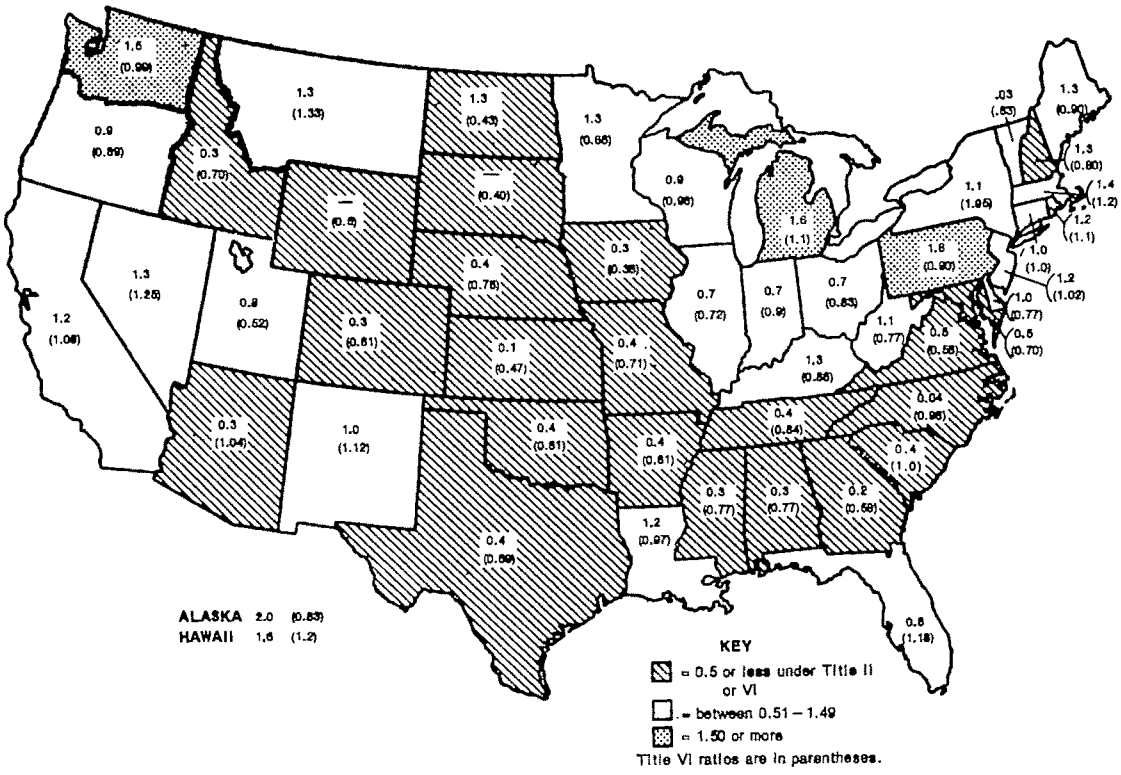


Figure 1. State unemployment—fund share ratios, CETA titles II and VI

ing of rural need for countercylical job creation funds does not coincide with the periods of peak PSE operation; and (*c*) rural areas do not apply for funds for which they are eligible. In addition to structural rural-urban differences that limit allocations to rural areas, certain administrative regulations may discourage rural participation in PSE programs. Finally, rural areas may be unable to utilize and absorb temporarily subsidized workers, making rural public service employment less effective for both participants and communities.

PSE allocations are made on the basis of local unemployment estimates, which are derived largely from local claims for unemployment insurance. As with the generation of any sample statistic, accuracy decreases as the sample size decreases. Rural area samples are smaller than urban samples because of smaller labor forces and because rural areas contain a higher proportion of industries (and jobs) not covered by unemployment insurance. Thus, the generation of local unemployment estimates largely from local unemployment insurance claims increases the margin of error associated with rural unemployment estimates (Wetzel and Ziegler, U.S. Dep. Labor 1960).

Since it is often assumed that the costs of unemployment increase nonlinearly (Comptroller General of the U.S.), PSE programs reserve a portion of available funds for areas of severe unemployment, usually defined as a rate of 6% or 6.5% for three consecutive months. To sustain this level of unemployment requires a labor force in which the unemployed continue searching for work rather than exiting from the labor force. Given the differing recession employment prospects in rural and urban areas, the rural unemployed probably lose their unemployed status more quickly than the urban unemployed. In rural areas, the unemployed can exhaust job search possibilities more rapidly, since rural areas contain fewer potential employers.[6] The rural unemployed are also afforded more opportunities to revert to self-employment or obtain part-time work in, e.g., agriculture.[7] Finally,

[6] Fewer potential employers may also retard labor force entry or reentry until an upsurge in employment is evident, i.e., relatively fewer employers in rural areas lower the cost of information about potential employment opportunities, thus dampening rural unemployment estimates while few jobs exist.

[7] More rural counties tend to have a higher proportion of their labor forces engaged in self-employment. Among the four most sparsely settled county classes, at least 25% of all families re-

rural persons experiencing unemployment have fewer incentives to remain in the labor force in order to search for work and retain eligibility to receive unemployment benefits, since a smaller proportion of the rural labor force is eligible for such benefits. Although rural need exists, it tends to be underestimated with present allocating statistics.

Another factor limiting PSE allocations concerns the temporary nature of public service employment programs and the timing of rural needs. Being countercyclical, PSE programs distribute funds for a limited period of time, biasing the funds distribution to favor areas experiencing severe unemployment. Since changes in the national unemployment rate govern the implementation and duration of PSE programs, the extent of local participation in the national program depends on the elasticity of local unemployment rates with respect to changes in national rates. If rural unemployment leads or lags changes in national unemployment or rural areas have high but stable rather than rapid changes in unemployment, they receive proportionately fewer PSE funds under the current program design.

Several economic factors combine to make the timing of peak rural unemployment vary from peak urban employment periods. Consumption theory predicts that, in a recession, consumers initially postpone their purchases of durable goods (First National City Bank). If durable goods manufacturing is concentrated in urban areas, then urban unemployment should begin rising soon after the onset of a recession. Unpublished USDA data show that in 1972 metropolitan durables manufacturing employment was 62% of total metropolitan manufacturing employment, while nonmetropolitan manufacturing employment was half durables, half nondurables, lending evidence to the hypothesis that urban areas are able to capitalize on their early unemployment rise when seeking limited PSE funds.

Buttressing the tendency of national PSE program operations to be geared to urban needs is the interaction of recent patterns of industrialization and profit-maximizing production decisions. If multiplant employers have been expanding most recently in nonmetropolitan areas, the newer, more efficient capital stocks of these plants should argue for their continued operation with declining product demand. Facing decreasing demand, the multiplant operator can either apportion production among plants or operate only the most efficient plants. Since 63.6% of the new manufacturing jobs created between 1960 and 1970 were in nonmetropolitan counties (Hines, Brown, and Zimmer, p. 36), the most recent vintage of the capital stock in these plants would argue for their relatively later shutdown and layoff periods.

The most serious impediment facing rural areas attempting to secure PSE funds is ineligibility and/or only limited eligibility. However, the administration of PSE programs accentuates rather than mitigates rural difficulties in securing funds. After area certification for PSE funds, local areas must submit approved plans for the expenditure of at least $25,000 (about 2.5 job slots) before funds are actually released. Included in the plan must be the goal of placing at least 50% of temporary PSE hires on the permanent public payroll at the program's conclusion.[8] Nonmetropolitan areas, traditionally providing a lower level of public services, are faced with a relatively higher transition burden even if the percentage transition goal is invariant. The two-stage application process, where rural areas initially apply for funds through their state governments, has produced an array of intrastate allocation formulae. Finally, the local contribution requirement and/or limits on funds used for capital outlays may force additional local outlays unless idle capital stock exists, since even labor-intensive public employment requires some capital.

Public service employment is designed to supplement and expand an area's current range of public services. Areas that are expanding public services have higher probabilities of retaining PSE hires and providing PSE participants with "meaningful" employment experiences, given an intention (in the absence of the PSE) to expand employment in certain directions anyway. If rural areas provide both lower levels of public services and a slower rate of increase in expanding public employment, rural participants are afforded a PSE experience less likely to gain

ported income from some form of self-employment in 1969, while only 10.5% of the core urban families had such income (Hines, Brown, and Zimmer, p. 97). Since unemployment rates among the self-employed are very low, the presence of more self-employed persons lowers the unemployment rate. If a 10% unemployment rate characterizes wage-and-salary workers in both rural and urban areas, and the urban labor force consists of ninety wage-and-salary workers for each ten self-employed persons, while the rural labor force contains a 75-25 division, then the urban unemployment rate of 9% exceeds the rural rate of 7.5% only because rural areas contain more self-employed persons.

[8] This transition requirement is made a goal only under title VI.

them permanent public employment. Until detailed participant data are available, one can only note that county governments (a dominant temporary public employer in nonmetropolitan areas) place the highest percentage of PSE hires in public works, the sector experiencing the lowest post-PSE retention rate.

Another factor that could make rural PSE's less effective than their urban counterparts is the composition of the unemployed in metropolitan and nonmetropolitan areas. Typically, the government labor force has skill characteristics that differ from those of the unemployed. In 1970, 42% of the unemployed had less than twelve years of education, while only 18% of government workers were not high school graduates (Fechter). Thus, even a temporary expansion of public employment produces a tendency to selectively choose participants from the unemployed labor pool. If rural areas contain more of the disadvantaged unemployed, the limitations on expenditures for training and capital outlays tend to direct poorer local areas toward simple tasks that are easy to begin and terminate. Just as the transition requirement can direct participants to particular program areas, the composition of the unemployed can make local decision makers aware of the trade-offs between the numbers and types of jobs created. Assuming unemployed labor pools with similar skill characteristics, local governments wishing to expand health or educational services require more highly skilled participants or more participant training than local governments augmenting construction, repair, or beautification efforts.

The transfer of the locus of control to smaller governmental entities, a prime impetus behind the CETA, assumes that local governments are better able to discern local needs. The CETA invests local prime sponsors with a great deal of influence over any PSE program in their jurisdiction. By deciding which job slots are created, local decision makers also determine the types of participants likely to be hired to fill the job slots created, the wage range and the amount of adjunct training offered, and the probability of retaining the PSE participant with the program's expiration. In rural counties, such local control tends to favor investment in physical infrastructure both because social welfare investments lack a constituency and because risk-adverting local decision makers tend to expand public services in directions already meeting public approval (Zimmerman). Thus, rural counties are likely to offer fewer permanent jobs and less adjunct training with their PSE programs.

Conclusions

This research has assessed geographic equity in the distribution of funds for one series of federal human resource programs, those that expend monies to create temporary public service jobs. Because the allocation formulae used to disburse funds could not capture important differences between rural and urban labor markets, rural need for funds is underestimated. Because rural areas could not enjoy "economies of scale" in applying for federal funds, administrative requirements may have discouraged rural participation. Whether the result of voluntary or involuntary decision, rural America did not receive the share of PSE funds expected, given its share of unemployment.

Most federal programs that affect the nation's stock of human resources have been reactive; they attempt to redress an identified disparity between national norms and group and/or area characteristics. Since these problems are generally identified first in urban areas, programs have been tailored to respond to urban needs. Because human resource programs are too small to meet the universe of need, equity dictates the use of uniform criteria for allocating limited funds, but such allocation formulae could be cognizant of structural differences between groups and/or areas.

To achieve distributional equity in the distribution of public service employment funds, the county (rather than the state) could be made the basic administrative unit. Allocations could be made on a per unemployed person or per capita basis, with per person supplements to counties experiencing severe unemployment or containing concentrations of, e.g., minority persons, poor households, or some other target group. Under such a program, a county's allocation would represent the sum of a per person allocation, derived by dividing the bulk of the total allocation by the national target population, plus per person supplements that reflect concentrations of particular target populations. Such an allocation mode could concentrate funds in local areas while redressing some of the more egregious interarea biases existent under current public service employment programs.

Merely changing the locus of manpower control would not, ipso facto, guarantee that areas of equal need receive equal shares of federal manpower funds. The lack of detailed intercensus data at the county level would force reliance on census benchmarks and subsequent estimates or new data-gathering efforts. Collection of such county level data would increase the cost of administering any PSE program, but the county level data would also be available to direct funding needs for other programs. The current ambiguity surrounding "correct" allocation formulae has shifted the dispute into the legal arena (Raskin). While no simple change can produce an equitable allocation formula, more decentralization could ensure that more remote areas received some minimum level of manpower funds.

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Daily Fluctuations in Campground Use: An Econometric Analysis

Ronald A. Oliveira and Gordon C. Rausser

Many recreation activities are characterized by fluctuating use levels over time. This paper presents a theoretical and quantitative analysis of fluctuations in campground use series. Theoretical use functions are specified as the reduced form of a demand and supply system, where the derived demand for campground use is based upon the household production approach to consumer demand theory. A pooled time-series cross-section econometric use model is specified, and its estimated parameters are presented. In addition, campground use series are modeled incorporating Box-Jenkins time-series analysis techniques. Econometric predictions are more accurate relative to autoregressive-integrated-moving-average (ARIMA) predictions.

Key words: campground use, econometric recreation model, recreation demand theory, time-series analysis.

Clawson and Knetsch have noted the problems associated with the variations in time patterns of outdoor recreation use. They also suggested that the time aspects of outdoor recreation use and more explicitly the "extreme time-peaking of demand" have not received sufficient attention in the literature. Barker has suggested expressing recreation carrying capacity in time-associated units. Stottlemeyer has also noted the fluctuations in use levels over the season or year and has suggested time scheduling of visitor use among national park developments so that developments would be used at optimal density and maintenance costs could be optimized. Moreover, the recent discussion by Archer and Shea on tourists' length of stay illustrates the usefulness of daily use models in forecasting daily tourist expenditures, waste treatment needs, water needs etc.

Campground use levels, which are the focus of this paper, may fluctuate considerably from day to day, even though the number of campsites occupied may remain more or less constant. Such fluctuations necessitate corresponding fluctuations in maintenance and regulatory personnel in order to avoid over- and understaffing problems. For instance, managers could easily adjust personnel levels with use level forecast horizons of a month or more in length. Although they may not be able to change personnel levels in the immediate short run, managers could alter the work locations, i.e., concentrate work efforts in certain campgrounds while temporarily ignoring others.

Although the problem of time-varying consumption levels is not limited to outdoor recreation, it has received little attention in the recreation literature. Recreation researchers have traditionally concentrated on explaining the use of a certain recreation activity over a cross section of such activities or the use of a particular type of site over a cross section of such sites (Boyet and Tolley; Clawson and Knetsch; Cicchetti, Seneca, and Davidson). Those studies that have considered recreation use over time have centered on predicting annual participation rates or levels (Clawson, Kalter and Gosse).

In light of the above comments, the purpose of this study is to construct alternative models with which to forecast daily campground use levels over a given season. Two empirical models are presented. The first, an econometric representation, is based upon a conceptual

Ronald A. Oliveira is an assistant professor of agricultural and resource economics, Oregon State University, and Gordon C. Rausser is a visiting professor of business administration, Harvard University.

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reduced form use model. It is assumed that the demand for campground use is part of a stepwise utility maximization process and that the present analysis is only concerned with the choice between campgrounds and between camping dates. More explicitly, the decision to camp and the decision on the length of stay are assumed to have been made by the users in the previous stage(s) of their decision process. The second empirical use model, an autoregressive-integrated-moving-average (ARIMA) representation, is fitted using the time-series analysis technique of Box and Jenkins and is employed as a sophisticated "naive" forecasting model, the results of which can be compared with those of the relatively more difficult to estimate econometric model. Although it is expected that the most fruitful application of the two empirical use models would be as input to a national forest recreation simulation analysis, the short-run forecasting abilities of the models are investigated.

Theoretical Formulation

The demand for campground use is assumed to be directly affected by the characteristics of the campgrounds and by the time and expenditures consumers allocate to campground use (i.e., camping). The theoretical foundations for these assumptions are based upon the household production function (HPF) approach to consumer demand theory (Michael and Becker, Ghez and Becker) and the characteristics approach to demand theory (Lancaster), where the latter is viewed as a special case of the former. Following the HPF approach, it is assumed that each camper or user obtains or "produces" basic consumption goods or characteristics from the act of camping at a certain campground, that, in turn, the characteristics are the direct arguments of the user's utility function, and that the user follows a sequential utility maximization process, where the utility function conforms to weak separability, to arrive at the optimal allocation of time and money to camping. Thus, the user derives his "full income" allocation or constraint to camping (Becker, Michael and Becker).

In the nth or camping stage of the consumer's utility maximization process, the user maximizes the portion of his overall utility function that is concerned with campground characteristics, subject to his full income camping allocation and the campground production relationships.[1] These latter relationships may be interpreted either as the user's ability to obtain or produce the desired characteristics from a campground or as the amount of various characteristics available from a campground. The user's derived demand for use of campground j on day t, say, x_{jt}, may be viewed as follows:

$$(1) \quad x_{jt} = f_d(Z_{jt}, s_c) \text{ for } j = 1, 2, \ldots, G \text{ and } t = 1, 2, \ldots, T,$$

where Z_{jt} is a vector of relative levels of basic campground characteristics associated with campground j on day t, s_c is the amount of full income allocated by the user to camping, G is the total number of campgrounds in the set from which the user will select, and T is the length of the relevant camping season.[2] Since it is assumed that the decision to camp and the decision on the length of stay have been made in the previous stage(s) of the user's utility maximization process, other recreation activities and their prices do not directly appear in equation (1) as arguments. Such factors enter into decisions made in previous stages and influence the level of s_c. Given that equation (1) is a derived demand function, the relative attribute or characteristic levels may be viewed as relative prices in the household production function context.

Aggregate demand for using campground j on day t (in terms of number of people) is the sum of all the individual household demands as specified in equation (1). Thus, the arguments of the aggregate derived demand function are the vector of campground characteristics (Z_{jt}) and the full income allocation to camping for all households, say, S_c. Such a specification of campground demand could be employed directly in the analysis of use if the supply of each recreational area is fixed and if supply is always greater than demand. In reality, only the stock of supply is approximately fixed in the short run. By stock of supply is

[1] Actually, the number of previous stages is not important to the present analysis, since this study is only concerned with what happens after the decision to camp has been made. The sequential utility optimization process in another recreation context is further discussed by Rausser and Oliveira.

[2] One might argue that the timing of the camping trip, i.e., the day selection, and the choice of a campground are results of separate decision stages. Such a distinction would need to be determined via personal consumer surveys. Furthermore, given that the objective of the present analysis is to examine variations in use between campgrounds over a given season, it is necesssary to treat the two items jointly.

meant the physical area itself (unit of land) and non–time-varying characteristics (e.g., number of sites). On the other hand, supply may also be interpreted as having a changing quality. In the context of campground use, the flow of supply may be interpreted as the changing quality and availability of supply (e.g., weather). Stock supply characteristics such as the number of campsites may be viewed as flow variables, i.e., changing over time, in a long-term analysis. In the present analysis, use is examined over a given season, and it seems unlikely that physical conditions such as existing facilities will be varied in the short run. Hence, the supply relationship for campground j may be expressed as a function of a vector of characteristics, some constant over the season and some time varying, associated with campground j. One possible interpretation of such a supply function is the number of users possible at area j, i.e., capacity, under varying quality conditions. The explicit definition of such quality conditions or criteria (Seneca and Cicchetti) would obviously be quite difficult to define explicitly and are beyond the scope of this paper. It seems reasonable to argue heuristically that the possible use level for a given "quality index" can vary as characteristics at the campground vary. In turn, the index of quality may vary with use if other conditions remain constant. Although management restrictions as to the number of people per campsite may set an upper limit, exogenous conditions such as weather may keep the total use of the campground below this level.[3]

Combining the above specifications, one obtains a simultaneous demand and supply system, the reduced form of which is campground use (Cicchetti et al.). More explicitly, the reduced form may be stated as

$$(2)\quad X_{jt} = x(Z_{jt}, Z_j, S_c) \text{ for } j = 1, \ldots, G \text{ and } t = 1, \ldots, T,$$

where X_{jt} is defined as the actual use (number of people) at campground j on day t, Z_{jt} is a vector of time-varying characteristics associated with campground j, Z_j is a vector of non–time-varying characteristics, and S_c represents the full income allocation to camping for all households.

As in most empirical applications, the theoretical specification in equation (2) needs to be altered somewhat to correspond to available data. The full income allocation variable S_c cannot be measured empirically. Theoretically, full income is a composite measure of the user's or household's value of time and income allocated to camping. The actual total use at all G campgrounds on day t, or X_{Tt}, is employed as a proxy variable for S_c.[4] Admittedly, these two variables are not equivalent; however, it is reasonable to assume a direct positive correlation between them. The use of any other time-varying reasonable proxy would necessitate the use of camper surveys in order to determine the amount of time and income devoted to this activity.[5] Furthermore, non–site-related exogenous variables such as real income allocations are not particularly desirable in this context, since an attempt is made to account for the choice of a campground across a set of campgrounds.

Two other factors that may be assumed to influence use but are not explicitly listed in equation (2) are past use at campground j and institutional calendar events. For example, past use may be treated as a time-varying characteristic of the campground that influences the household's expectations of congestion at the campground. This interpretation of past use is the result of only one possible structural formulation; it also could result from a partial adjustment formulation, among others.

A priori, one would expect institutional calendar events such as holidays and weekends to have positive influence on use. On the other hand, the influence may be negative if people expect crowded conditions on holidays and stay at home. Holidays and weekends may also influence use via the household "production" process, i.e., many individuals may only be able to engage in the camping "production relationship" on such days. One could therefore assume that their productive capability in this case is limited to nonwork days.

In light of the above discussion, the use function to be addressed empirically in the subsequent analysis may be written as

[3] Clearly, there is a definite need for further theoretical analysis in this area. Nevertheless, the main point is that supply is not fixed in the short run but is a function of the characteristics (some variable) of the campground.

[4] Given that an exogenous factor varies and is unobservable, it follows from the viewpoint of bias that it is better to use a proxy rather than omit this exogenous variable (Wickens).

[5] The variable X_{Tt} could appear in a use function that is motivated by a different structural specification. For instance, it would appear directly if equation (2) was based on an allocative mechanism that allocates a given sum of use over all the possible campgrounds. Estimation and forecasting problems associated with the use of X_{Tt} are noted below.

(3) $X_{jt} = x(Z_j, Z_j, X_{j,t-k}, X_{Tt}, D_t, U_{jt})$
for $j = 1, \ldots, G$ and $t = 1, \ldots, T$,

where D_t is a vector representing institutional calendar events and U_{jt} is a stochastic error term.

Econometric Use Model

Given the above use function and the availability of cross-section data over time, equation (3) may be expressed as a pooled cross-section and time-series (CTS) model. In this context, equation (3) is interpreted as a single equation linear model with $N = G \times T$ observations. With regard to the data base for the constructed model, the campground use series, i.e., X_{jt} in equation (3), was obtained from campground registration forms for twenty-one U.S. Forest Service campgrounds in California for 1970. The observations employed in the analysis were from 1 May to 31 October 1970, resulting in 184 daily use observations. Although the original use series was in daily observations, the econometric model was estimated employing only Saturday observations, since the original series revealed Saturday as generally the heaviest use day of the week. In addition, it was thought that forecasts of Saturday use would be sufficient for most management purposes. Furthermore, the daily observations are most likely characterized by such random fluctuations that it would be difficult to obtain stable econometric predictions for this data base.

Characteristic Variables

The twenty-five characteristics selected for the empirical analysis are listed in table 1. Clearly, some of the characteristics may be measuring the same attribute as another characteristic. Since it was not obvious which characteristics should be omitted, and it was desirable to maintain as much information as possible, it was decided to use the theory of principal components to find a smaller number of variables that would capture most of the variability of the recorded characteristics set. The resulting principal components of the characteristics variables are essentially employed as proxy or instrument variables (Dhrymes, Morrison).

The decision on the number of principal components to use was based upon the percentage of the total variability in the original characteristics "explained" by each principal component. The proportion of the total "vari-

Table 1. Campground Characteristics

Variable	Estimated Regression Coefficients[a]
1. Number of camp units	−4.27
2. Flush toilets available[b]	12.67
3. Vault toilets available[b]	−5.36
4. Combination of flush and vault toilets[b]	15.46
5. Boat launching available[b]	−3.48
6. Boating available[b]	−3.95
7. Swimming allowed[b]	−2.63
8. Fishing facilities[b]	2.51
9. Lake adjacent[b]	−7.11
10. Stream adjacent[b]	9.77
11. Elevation (feet)	−3.13
12. Number of campgrounds within radius of 5 miles	5.33
13. Number of camp units at above campgrounds	1.37
14. Precipitation in June 1970 (1/100 inch)	2.55
15. Precipitation in July 1970 (1/100 inch)	8.85
16. Precipitation in Aug. 1970 (1/100 inch)	0.13
17. Precipitation in Sept. 1970 (1/100 inch)	2.87
18. Precipitation in Oct. 1970 (1/100 inch)	9.85
19. Average annual precipitation, 1965–70 (1/100 inch)	8.14
20. Total precipitation, 1970 (1/100 inch)	9.14
21. Total snowfall, 1970 (1/10 inch)	2.94
22. Average annual snowfall, 1965–70 (1/10 inch)	5.87
23. Number of lakes within radius of 5 miles	7.05
24. Minimum travel time to nearest wilderness area (minutes)	−4.71
25. Population accessibility	−4.87

[a] Estimated coefficients for standardized deviates of campground characteristics using time-series cross-section model in equation (4).
[b] Dummy variable, which equals one if the facility is available at the campground, equals zero otherwise.

ance" in the scatter of the twenty-five campground characteristics attributable to the first seven principal components was 0.87. These components were the only ones that had corresponding eigenvalues greater than one in magnitude. The eighth component accounted for less than 4% of the total variation in the characteristics. Thus, it was thought that the first seven principal components accounted sufficiently for the total variation and that the gain from adding another principal component would not be worth the loss in degrees of freedom.[6]

There is not general agreement as to the interpretability of principal components in an economic context. Dhrymes states that principal components, especially when derived from a correlation matrix, cannot generally be interpreted in a meaningful way. Morrison, however, suggests that the elements of the eigenvectors, i.e., their magnitude and sign, may be interpreted as indicating the importance of the corresponding variable (or campground characteristic in this case) in contributing to that specific component. If one only considers those eigenvector values of a relatively large value, the dimensions of the various principal components can be defined in terms of the variables corresponding to these large eigenvector values (Hendee et al.). By considering only those eigenvector values with absolute values greater than or equal to 0.25, the dimensions of the seven respective campground characteristics principal components are interpreted as follows: (*a*) higher than average precipitation at a relatively low elevation with swimming and fishing available; (*b*) lake with boating and alternative campgrounds available or nearby; (*c*) fishing stream and nearby lakes; (*d*) stream and nearby lakes but with relatively smaller number of camp units and close to a wilderness area; (*e*) low snow fall, stream, and remote; (*f*) primitive toilet facilities without nearby campgrounds and lakes but with boating; (*g*) without combination flush and vault toilets but not close to a wilderness and with September precipitation.

Temperature Variables

In the conceptual discussion of use functions, weather conditions are given as an example of a campground time-varying characteristic. Time-varying characteristics are viewed as components of the flow of supply that influence the accessibility of a campground. Similarly, when treated as a time-varying characteristic, weather conditions will have a bearing on the overall attractiveness of a campground and influence its demand.

Since little precipitation occurred during the observation period employed (i.e., 1 May–31 October 1970), it was decided to measure main weather conditions by temperature readings. Daily maximum and minimum temperature readings were recorded for the weather reporting station nearest each campground and for a central city in each California county during the observation period. To make the analysis manageable, temperature readings for the three counties from which the most users came to each campground were employed.[7]

Use is not assumed to be directly influenced by the actual county temperatures but rather by the relative difference between the "at-home" temperature, i.e., the county temperature, and the temperature at the campground. Specifically, it is hypothesized that if the "home" (county) temperature is relatively hot, say, 100°, and if the campground vicinity is experiencing mild or cooler temperatures, say, 75°, then there will be a strong positive temperature attraction influence on the people in the country. Given this hypothesis, a temperature attraction variable was constructed. This variable ranged in magnitude from 10 to 0, where 10 is the maximum amount of attraction. Using only the three heaviest use counties associated with each campground, each possible county-area temperature combination (within 5° intervals) was assigned a value ranging from 10 to 0, based upon the temperature attraction hypothesis. The assigned value was related to the difference between the campground and the county temperatures and the actual county and campground temperatures. In other words, a difference of 10° would receive different values depending upon the actual county temperatures. It was assumed that, if the county's temperature was low, a warmer area would be attractive up to a point, i.e., until the campground became too warm.[8]

[6] The eigenvalues and their corresponding eigenvectors for the first seven principal components along with their contribution to the total "variance" are available from the authors upon request.

[7] Admittedly, by excluding the other fifty-five California counties, one is ignoring information; however, it was thought that this omitted information was minimal, since in most cases only a few counties contributed to the majority of use at each area. In fact, the actual empirical analysis indicates that only the heaviest origin use county has a significant influence on use.

[8] The values assigned for the maximum and minimum temperature combinations are available from the authors upon request. As expected, the values selected are somewhat arbitrary and

Empirical Econometric Results

Alternative forms of time-series exogenous variables were considered and analyzed in the context of equation (3).[9] Not surprisingly, many of the temperature variables were eliminated due to extremely high intercorrelations, i.e., the temperature attraction variables associated with the three heaviest use counties for each area were often highly correlated due to similarities in temperatures as well as similarities in travel times (which were used to form interaction variables). The following variables were selected as predetermined variables for the final model, where t represents Saturday or weekly observations: total use at all campgrounds on Saturday t (X_{Tt});[10] use lagged one observation (X_{jt-1}); use lagged two observations (X_{jt-2}); temperature attraction variable (minimum temperatures) associated with heaviest use county (Z_{j1t}); minimum temperature at campground j on Saturday t (Z_{j2t}); interaction term formed by dividing Z_{j2t-1} by the travel time in minutes from the heaviest use county to campground j (Z_{j3t}); first characteristic principal component (based upon standardized deviates of the characteristic variables) of campground j (Z^*_{j1}); second through seventh characteristic principal components of campground j ($Z^*_{j2}, \ldots, Z^*_{j7}$).

The pooling of the cross-section observations for the eighteen campgrounds and the twenty-five Saturday observations resulted in far more pooled observations than needed for estimation purposes.[11] Since it is also desirable to have separate data with which to test an econometric model, especially one to be used for forecasting, some of the campground data were saved for testing the forecasting performance of the estimated model. Thus, the eighteen campgrounds were divided into two arbitrary groups, A and B. The econometric estimation results for the pooled data from group A are given below. In a subsequent section, the results of using the estimated model to forecast the use levels for group B based upon the actual data for that group are presented. The estimated model based upon group A data is as follows:

$$
\begin{aligned}
(4)\quad X_{jt} = {} & -37.3 + 0.0084\,X_{Tt} + 0.77\,X_{jt-1} \\
& (-1.0)\ (2.9)\qquad (11.0) \\
& -0.12\,X_{jt-2} + 10.1\,Z_{j1t} - 1.8\,Z_{j2t} \\
& (-1.9)\qquad (2.1)\qquad (1.9) \\
& + 399.5\,Z_{j3t} + 15.4\,Z^*_{j1} - 7.9\,Z^*_{j2} \\
& (3.1)\qquad (3.8)\qquad (-1.9) \\
& -0.23\,Z^*_{j3} + 9.6\,Z^*_{j4} + 6.0\,Z^*_{j5} \\
& (-0.02)\qquad (0.7)\qquad (0.7) \\
& - 18.4\,Z^*_{j6} - 19.2\,Z^*_{j7} \text{ for } j = 1, \ldots, G \\
& (-2.1)\qquad (-2.0) \\
& \text{and } t = 1, \ldots, T,
\end{aligned}
$$

where the numbers in parentheses are the approximate t-statistics for the corresponding coefficient estimates and $R^2 = 0.77$. The time-series predetermined variables had estimated coefficients that were of the expected sign and that were significantly different from zero.[12] One might question the fruitfulness of including the temperature attraction variable (Z_{j1t}), the campground minimum temperature (Z_{j2t}), and the temperature interaction variable (Z_{j3t}) all in the same equation. As one would expect, these variables are highly correlated; however, they all have significant coefficient estimates, indicating they may account for different influences on use and should be useful for forecasting purposes. The temperature attraction variable is assumed to account for the "drawing power" of temperature differences between the campground and its heaviest use county. On the other hand, the significant negative coefficient estimate for the campground's minimum temperature suggests that the actual minimum temperature has a negative relationship to use. Moreover, this suggests that there are temperature effects not fully accounted for in the attraction variable. There seems to be a contradiction between the estimated coefficients for Z_{j2t} and Z_{j3t}. A priori, one would expect the coefficients for

influenced by subjective opinions. What is important, however, is that the values should be selected in a consistent manner. If so, based upon the hypothesis given above, one would expect to find a positive relationship between use and the temperature attraction variables.

[9] The residual terms in equation (3) are assumed to follow a first-order auto-regressive scheme and are specified as cross-sectionally heteroscedastic and mutually uncorrelated. To account for these problems and for the relationship between the lagged dependent variables and the error terms, a five-stage procedure is employed to obtain consistent estimates of the parameters. The details of this estimation procedure are reported in Rausser and Oliveira.

[10] Powell examines an aggregate variable similar to X_{Tt} as a common regressor in a system of equations and shows that in this context the disturbance covariance matrix is singular. This problem is obviously avoided in the present single equation CTS model.

[11] Of the original twenty-one campground use series, three were omitted due to apparent data inaccuracies.

[12] The use of the word significant is not strictly correct, since the ratio of the estimated coefficient to its associated standard error (under the null hypothesis that the true unknown parameter is zero) is only approximately distributed as a t (Rausser and Oliveira).

these variables to have the same sign; however, the expected linear relationship between travel time and use is negative. Thus, the expected relationship between the reciprocal of travel time and use would be positive. The empirical results suggest that the positive effect of the reciprocal of travel time outweighs the negative influence of the minimum temperature, resulting in a net positive relationship.[13]

The interpretation of the estimated coefficients for the principal component variables is somewhat ambiguous. Nevertheless, those coefficients that are significant suggest that the presence of swimming and fishing facilities are positive influences on use levels. These results also suggest those campgrounds with primitive toilet facilities and those located at longer distances from other campgrounds have lower use levels. This implies that clusters of campgrounds are more popular and that campers prefer flush toilets to vault.

Another procedure for examining the regression results pertaining to the campground characteristics is to transform the estimated coefficients of the principal component variables to coefficients for the standardized deviates of the original characteristic variables. These estimated coefficients are presented in table 1. Again, the relatively larger coefficients suggest the importance of flush toilet facilities and a stream. The coefficients for characteristics 1, 12, and 25 imply that clusters of larger campgrounds close to population centers are characterized by higher use levels. It also appears that an adjacent lake is not a positive attraction but that nearby lakes are. The empirical results imply that *ceteris paribus* campgrounds immediately adjacent to a lake will have relatively lower levels of use than those that are near or within a short distance to lakes. The large positive values for the precipitation characteristics are surprising and seem contrary to reasoning,

Lime found that fishing and waterfront campsites were important variables in the selection of campgrounds. The results presented above, although somewhat ambiguous, support his findings. Shafer and Thompson also noted the high positive correlation between use levels and water-recreation variables and campground size.

[13] In addition, the sign of this interaction term may be influenced by the lag factor. The direction of such an influence is unclear. The above expectations with respect to signs of coefficients are only correct if all variables are orthogonal—they obviously are not.

Box-Jenkins Campground Use Model

In the previous section, an econometric representation of the campground use model specified in equation (3) was presented. This section presents an alternative model of the campground use series that does not directly include exogenous variables and that is estimated with daily rather than weekly observations. The use series is modeled on the basis of its present and past observations in terms of an autoregressive-moving-average (ARMA) model as developed by Box and Jenkins.[14]

Incorporating the notation of Box and Jenkins, the general multiplicative seasonal autoregressive-integrated-moving-average (ARIMA) model for a seasonal series X_t, $t = 1, 2, \ldots, T$, with a known period s can be written as

$$(5)\quad \phi_p(B)\Phi_P(B^s)(1-B)^d(1-B^s)^D X_t = \theta_q(B)\Theta_Q(B^s)a_t,$$

where a_t is a random disturbance assumed to be distributed as $N(0, \sigma^2)$; B is a backward shift operator such that $BZ_t = Z_{t-1}$ and $B^kZ_t = Z_{t-k}$; $\phi_p(B)$ is the regular autoregressive operator of order p, i.e., $\phi_p(B) = (1 - \phi_1B - \phi_2B^2 - \ldots - \phi_pB^p)$; $\Phi_P(B^s)$ is the seasonal autoregressive operator of order P; d is the number of regular differences; D is the number of seasonal differences; $\theta_q(B)$ is the regular moving average operator of order q, i.e., $\theta_q(B) = (1 - \theta_1B - \theta_2B^2 - \ldots - \theta_qB^q)$; $\Theta_Q(B^s)$ is the seasonal moving average operator of order Q; and s is the order of the seasonal difference. Equation (5) is an ARIMA model of order (p, d, q) times $(P, D, Q)_s$, explained in some detail by Box and Jenkins.

Using a seasonal difference of order 7, i.e., a weekly season, and daily observations, the nine campgrounds in group A are each fitted to equation (5) following Box and Jenkins' four-stage modeling procedure, i.e., (*a*) specification, (*b*) identification, (*c*) estimation, and (*d*) diagnostic checking. (The estimated autocorrelation and partial autocorrelation functions for the use series and the results of the diagnostic residual tests are available from the authors upon request.) The "best fitting" model for each campground in group A is listed in table 2. Campgrounds 1, 10, 14, and 20 are relatively accessible to large population centers and, consequently, their use series are

[14] One can easily demonstrate that an ARMA model is derivable from a structural econometric model if each exogenous variable is assumed to be generated by an ARMA process (Rausser and Oliveira).

Table 2. Campground ARIMA Models

Campground	Model	Estimates of Parameters	
1. Table Mountain	$(1 = \Phi_7 B^7)(1 - B)(1 - B^7)X_t$	$\hat{\Phi}_7 = -0.45$	$\hat{\theta}_1 = -0.22$
	$= (1 - \theta_1 B)a_t$		
6. O'Neil Creek	$(1 - \phi_2 B^2)(1 - B)X_t$	$\hat{\phi}_2 = -0.46$	$\hat{\theta}_6 = -0.19$
	$= (1 - \theta_6 B_6 - \theta_{10} B^{10})a_t$		$\hat{\theta}_{10} = 0.11$
8. Almanor	$(1 - \phi_1 B)(1 - \Phi_7 B^7)(1 - B)X_t$	$\hat{\phi}_1 = 0.40$	$\hat{\theta}_{11} = 0.20$
	$= (1 - \theta_{11} B^{11} - \theta_{20} B^{20})a_t$	$\hat{\Phi}_7 = 0.30$	$\hat{\theta}_{20} = 0.26$
10. Sunset	$(1 - \phi_1 B)(1 - \Phi_7 B^7)(1 - B)X_t$	$\hat{\phi}_1 = 0.20$	$\hat{\theta}_3 = 0.34$
	$= (1 - \theta_3 B^3 - \theta_7 B^7 - \theta_{10} B^{10})a_t$	$\hat{\Phi}_7 = 0.90$	$\hat{\theta}_7 = 0.44$
			$\hat{\theta}_{10} = -0.15$
12. Chilcoot	$(1 - \phi_1 B - \phi_4 B^4)(1 - B)(1 - B^7)X_t$	$\hat{\phi}_1 = 0.26$	$\hat{\theta}_2 = 0.21$
	$= (1 - \theta_2 B^2)(1 - \Theta_7 B^7)a_t$	$\hat{\phi}_4 = -0.24$	$\hat{\Theta}_7 = 0.82$
14. Marion Mountain	$(1 - \phi_5 B^5)(1 - B)(1 - B^7)X_t$	$\hat{\phi}_5 = -0.19$	$\hat{\theta}_3 = 0.21$
	$= (1 - \theta_3 B^3)(1 - \Theta_7 B^7)a_t$		$\hat{\Theta}_7 = 0.40$
16. Hirz Bay	$(1 - \phi_8 B^8 - \phi_9 B^9)(1 - B)X_t$	$\hat{\phi}_8 = 0.18$	$\hat{\theta}_1 = -0.36$
	$= (1 - \theta_1 B - \theta_{11} B^{11})a_t$	$\hat{\phi}_9 = -0.14$	$\hat{\theta}_{11} = 0.23$
18. Oak Grove	$(1 - \phi_1 B)(1 - B)(1 - B^7)X_t$	$\hat{\phi}_1 = 0.31$	$\hat{\theta}_2 = 0.20$
	$= (1 - \theta_2 B^2 - \theta_{16} B^{16})(1 - \Theta_7 B^7)a_t$		$\hat{\theta}_{16} = -0.25$
			$\hat{\Theta}_7 = 0.91$
20. Indian Valley	$(1 - \phi_1 B)(1 - B)(1 - B^7)X_t$	$\hat{\phi}_1 = -0.08$	$\hat{\theta}_4 = 0.15$
	$= (1 - \theta_4 B^4)(1 - \Theta_7 B^7)$		$\hat{\Theta}_7 = 0.79$

characterized by large weekly cycles, i.e., heavy weekend use. Their ARIMA models are all characterized by a relatively large seasonal parameter, and all, except that for campground 10, have a seasonal difference. In contrast, campgrounds 6 and 16 are relatively isolated from major population areas and are most likely characterized by less fluctuating use levels, i.e., campers will tend to stay for more than just a weekend. As expected, their models do not contain seasonal parameters or seasonal differences. Campground 16 is located next to a lake and has boating facilities, which may encourage longer camping stays. Campgrounds 8, 12, and 18 have models with dominant seasonal aspects but are not relatively accessible to large population areas. These three campgrounds may appeal to weekend campers, since campground 8 is quite large (i.e., will not fill up as quickly) and the other two offer more modern facilities such as flush toilets.

Forecasting Campground Use

The econometric and ARIMA models presented in the last two sections are used as forecasting equations in this section. The campgrounds are divided into two groups so as to have a "postsample" set of data with which to test the forecasting models. Given the campground postsample period consisted of observations on different campgrounds, i.e., group B, it was decided to select one model from the ARIMA models listed in table 2. Preliminary estimations for all of the group A campgrounds using all the models in table 2 indicate that the more accurate, in terms of root-mean-square error (RMSE), was the model for campground 6. Hence, this model is employed as a representative campground ARIMA forecasting model.

Independent econometric and ARIMA sample period estimations and postsample period predictions are made for seven-, fourteen-, and twenty-eight-day estimation and forecast spans. These time spans are considered to be adequate for testing the short-run forecasting performances of the models. The econometric model is based upon Saturday observations. Thus, the above forecast spans correspond to one, two, and four period ahead predictions. For the ARIMA estimations and projections, actual seven-, fourteen-, and twenty-eight-day spans are used, since these models are estimated with daily observations. For the econometric estimations and predictions, the exogenous variables are set at their actual levels. These actual values lead to *ex post* forecasts from the econometric model. Such predictions may be viewed as forecasts

that would have been made by a forecaster endowed with perfect foresight with regard to future values of exogenous variables (Nelson, p. 902). In a practical situation, forecasted values of the exogenous variables need to be employed. Forecasts of X_{Tt} at first glance appear to be the most difficult to obtain. Fortunately, forecasts of aggregate annual use are generally made for most recreation areas such as a national forest. One could distribute an estimate of aggregate annual use over the season by using a modified ARIMA model and substitute this proportioned daily estimate in the forecasting equation.

The RMSE's for the sample period estimations and postsample (i.e., group B) predictions using the econometric and ARIMA models independently are given in table 3. The sample period econometric estimations are generally more accurate relative to the ARIMA estimations. The econometric RMSE's are smaller than the seven-day ARIMA RMSE's for six of the nine sample period campgrounds. Since the sample and postsample observations are composed of different campgrounds, accuracy of the models for the two periods cannot be directly compared. For the postsample period the ARIMA predictions are more accurate relative to the econometric predictions for seven of the nine campgrounds. One possible explanation for this reversal of the relative accuracy is the observation base for the econometric model, which is composed of different campgrounds (i.e., cross-section and time-series observations), while the ARIMA model is based upon observations of only one campground. The econometric model may be too aggregative relative to the ARIMA model to be useful in nonconstruction period predictions.

Predictions from both the econometric and ARIMA models are combined by various schemes of composite predictions. For example, by regressing the actual use levels on the two forms of predictions, we obtain estimates of "composite weights" in terms of the regression coefficients. The estimated composite weights are then employed to obtain linear composite predictions. If one assumes the two predictions to be independent, the composite weight estimates can also be used as a measure of the relative importance of each predictor, i.e., econometric or ARIMA, in forming the composite prediction. Given that the econometric predictions employed actual values of exogenous variables, the econometric prediction weight generally is close to one. With each composite procedure tested, it was found that more accurate results in terms of RMSE are obtained with the composite predictions than with the individual predictions alone. (The results of the composite predictions analysis are available upon request. A more detailed discussion of composite prediction in the context of wilderness use is presented in Rausser and Oliveira.)

Conclusion

The main conclusion of the above analysis is that daily campground use levels over a season can be modeled with some success. Two types of empirical models were employed. The first, a pooled cross-section and time-series single equation econometric model, was

Table 3. RMSE for Econometric and ARIMA Predictions

	Campground								
Period and Model	1	6	8	10	12	14	16	18	20
Sample period									
Econometric	83	18	108	67	38	26	61	72	29
ARIMA									
7-day	119	9	115	70	48	28	60	70	34
14-day	152	14	182	111	62	37	104	77	48
28-day	219	18	292	148	84	53	168	119	66
Postsample period									
Econometric	184	128	38	101	48	59	82	144	133
ARIMA									
7-day	116	48	29	74	57	74	60	105	71
14-day	160	76	46	92	78	86	75	188	113
28-day	180	115	76	127	117	120	99	322	153

based upon a causal reduced form use model. The estimated coefficients of the econometric model agreed with the expected causal relationships, and the overall model provided relatively more rigorous support for previous recreation research findings. The ARIMA models, the second empirical approach, provided a time-series model to compare with the more complex and difficult-to-estimate econometric model. Although the ARIMA model provides no information as to the causal factors behind campground use and its fluctuations, the model is relatively easy to employ and could be useful in structuring the lag relationships of an econometric model (Rausser and Oliveira).

The forecasting performance of the two models was also analyzed. Since actual values of the exogenous and lagged endogenous variables were employed to obtain the econometric predictions, it was not surprising that they were more accurate than the ARIMA predictions. It is doubtful, in an application where it would be necessary to use forecasted values of the exogenous variables, that the econometric predictions would be superior to the ARIMA values. The accuracy of forecasts in terms of RMSE can often be improved by combining the two separate predictions. For instance, in this application, the RMSE of the composite predictions were found to be, at a minimum, 5% smaller than the RMSE of the more accurate of the two individual predictions.

One of the more interesting features of the above discussion is the incorporation of the household production function concept into recreation demand analysis. This seems to be an intuitively appealing way to view recreation demand and is quite similar to the "multiple satisfaction approach" to hunting as described by Hendee. A fruitful extension of this paper would be a theoretical development of recreation demand based upon a combination of the HPF approach with the sociological implications of the multiple satisfaction approach. Such an analysis would hopefully investigate the desired attributes or characteristics of a camping experience, i.e., the basic commodities which the user is seeking or "producing" via campground use.

The results generated in this paper can be employed directly or indirectly in more applied contexts. Initially, direct benefits can be obtained by using the use time-series models, especially the ARIMA type, to allocate and disaggregate the annual use level predictions from government agencies (U.S. Dep. Interior). Projections of annual use could be distributed over the season in ARIMA fashion if one assumes various starting levels. Moreover, a causal model such as the econometric model discussed above could be employed to allocate aggregate use projections across recreation subareas and to forecast peaking problems over time as well as space. Such projections could also be made available to the public in order to forestall crowding conditions and turn-aways.

More indirect benefits of the above analysis could be obtained by employing daily use models, such as the ARIMA or econometric model presented above, in large-scale recreation systems models or in dynamic aggregate demand studies. The use equations, or similar ones, could serve as exogenous inputs into a national forest recreation simulation model, where recreation use levels at several different campgrounds and the resulting traffic flows and physical impacts are analyzed over time. Such a simulation analysis could be similar to the wilderness area simulation model developed by Krutilla and Smith. Desirable addition to the present analysis in such an application would be the development of quantitative models for camper arrival rates as well as the length of stay.

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Income Distributional Effects of the California Land Conservation Act

David E. Hansen and S. I. Schwartz

The distribution of program benefits of California's use-value assessment program has been a major issue in the political debate concerning the program's desirability. This study examines the income distributional effects of program benefits for a sample of participants in Sacramento County. The fraction of benefits received by lower income landowners was quite large when compared with their share of total income. Benefits received by lower income farmers were sufficient to cause a significant positive shift in farm income distribution, as measured by the Gini coefficient. For nonfarmers, the shift in the income distribution was slight.

Key words: agricultural land preservation, income distribution effects, use-value assessment.

Although most public programs do not contain explicit distributional goals, the incidence of their costs and benefits may become a major political issue. Under such circumstances, politically relevant policy analysis requires that distributional information be provided to decision makers so that informed decisions can be made. The California Land Conservation Act (CLCA) provides an example of a program where the distribution of benefits has become a major political issue even though distributional goals were not explicitly stated in the Act. This paper discusses the emergence of the distributional impacts as an important issue and analyzes the incidence of program benefits among CLCA participants in Sacramento County. The methods and findings should aid policy makers in California as well as other states where similar programs have been enacted or are being considered.

CLCA Background

The primary goals of the CLCA are to preserve prime agricultural land, discourage urban sprawl, and maintain a viable agricultural economy in California.[1] A principal feature of the CLCA is the contractual agreement between landowner and the appropriate local government (usually the county) under which the landowner must retain land in agricultural or related open space use for a minimum of ten years. In return, the land is taxed on the basis of income for agricultural use, rather than on the land's market value. The contract is automatically extended each year unless either party issues a notice of contract nonrenewal. If not renewed, the contract enters a nine-year run-out phase, which requires land to be assessed at an increasing rate that is higher than use value but lower than market value. Of the thirty-five states that at latest count have adopted use-value legislation, California is considered to have one of the two strongest programs because of the stability provided by the long-term contract (Gloudemans).

Political Support and Success of the CLCA

Original political support for the CLCA came largely from the agricultural sector and from

David E. Hansen is an associate professor of agricultural economics and S. I. Schwartz is an associate professor of environmental studies, University of California, Davis.

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[1] The CLCA is also widely known as the Williamson Act. The legislation establishing the Act can be found in the California *Government Code*, sections 51200–295. More detailed discussions of the important provisions of the CLCA are available in Wagenseil and in Stanford Environmental Law Society. An excellent description of use-value assessment programs throughout the United States is contained in Gloudemans.

conservation interests who endorsed the legislation because of its promise for preserving open space and agricultural land (Snyder). By 1973, it was clear that political support for the program had broadened. At a legislative hearing on the CLCA, testimony in support of the Act was given by the California Farm Bureau Federation, California Cattleman's Association, and California Forest Protection Association, as well as by the California Chamber of Commerce, representatives of the County Supervisors's Association of California, the County Assessor's Open Space Committee, and individual county planning directors (California Legislature 1973). In 1975, a task force on the preferential assessment of property, established by the legislature to recommend changes in the CLCA, recognized the support and acceptable performance of the Act in recommending that "all agricultural lands in commercial use . . . should be eligible for preferential treatment" (Hauck and Odland).

With forty-six out of the state's fifty-eight counties participating as of 1975, the program is generally considered to be successful in terms of overall participation. The total enrolled acreage was over 13.7 million, or approximately 44% of all privately owned agricultural land in the participating counties. Of this total, 4.18 million acres were classified as prime agricultural land, representing 40.7% of the total prime land in the participating counties.[2] Tax reductions from CLCA contracts amounted to $18.4 million in fiscal year 1974–75 and were estimated at $22.1 million for 1975–76 (California Resources Agency, Dep. Conservation).[3] Thus, to the extent that property tax relief contributes to a viable agricultural industry, the Act may be judged to be successful in meeting one of its goals. However, despite the high enrollments and the stability of the long-term contracts, the CLCA has been criticized for its limited influence on land conversion at the urban fringe (Schwartz, Hansen, and Foin; Gustafson and Wallace). Undoubtedly, the mixed success in meeting all of its explicit goals has been a factor in the increased political interest in the distributional impacts of the Act.

A number of writers have emphasized the need for greater attention to be given to distributional impacts—because of the political significance of such information or because of the belief that such information should be part of a comprehensive evaluation (Maass; Bonnen; Bromley, Schmid, and Lord; Kalter and Stevens). In our view, the need for distributional analysis is especially strong for the CLCA program because the distribution of benefits has become an important policy issue in California and is likely to become important in other states that have use-value assessment programs.

Several reasons exist for the emergence of distributional impacts as an important issue. There is widespread belief that the CLCA is intended to aid (or should be directed towards) smaller landowners who, as a group, are perceived to be less able than others to withstand the tax increases at the urban fringe or near rural subdivisions (Fellmeth, Sheedy, Odland). The use of preferential taxation to aid the small farmer has been supported by legislators, public interest advocates, land reform groups, and rural development groups ("How Rich People Farm the Treasury," Rural America). Such public support for the small farmer may also be traced to various federal programs and, in recent years, to the growing reaction to very large corporate-owned agricultural enterprises and the entry of syndicates into agriculture for the purposes of obtaining tax loss benefits.[4]

Undoubtedly, a major impetus for raising the distribution of CLCA benefits to a prominent political position came from a Nader task force study led by Fellmeth. In the strongest criticism of the CLCA to date, the program was faulted for bestowing millions of dollars of benefits upon giant corporate landowners, while providing little benefit to small landowners. The evidence consisted of a list of the largest beneficiaries of the Act, the amount of land each had enrolled, and the total tax reductions received. The list does indeed include giant corporations, some primarily nonagricultural, who accounted for "over one-fifth of all land affected by the Act" (Fellmeth, p. II-37). The attack struck a responsive chord with some members of the

[2] These estimates are based on a state inventory of agricultural lands (California Legislature 1969) and 1975 enrollment figures. The percentage of eligible prime land that is enrolled would be somewhat higher since some prime lands are not eligible because of location or size of parcel. In the total agricultural land estimate, this is probably more than offset by some contracted forest lands not included in the agricultural land totals.

[3] Part of this tax loss to local governments was reimbursed by the state's subvention program, which repaid $10.47 million in 1974–75 and was expected to reach $11.20 million in 1975–76 (California, Resources Agency, Dep. Conservation).

[4] At least one state, Minnesota, has restricted participation to noncorporate owners in its use-value assessment program (Rural America).

state legislature, and preliminary efforts were made to restrict participation in the CLCA program on the basis of size of enrolled acreage, distance of residence from enrolled land, levels of benefits paid, and corporate status of participants (Gonzales, Schwartz et al.). Although legislation restricting enrollment has not resulted, interest remains in such restriction. The impact of the Fellmeth criticism and the continuing importance of the distributional issue was noted recently by Wallace, now director of the State Department of Food and Agriculture, and Gustafson:

> On the basis of data on the concentration of tax reductions in 1970, the California Land Conservation Act of 1965 has been criticized because large corporate-conglomerate landowners have obtained very large tax reductions as a result of the Act (Danielson 1971; Fellmeth 1971). Current data on the distribution of tax reductions are needed. If it cannot be demonstrated that the distribution of tax reductions has become less concentrated since 1970 (which seems unlikely), support for the Act in the future may be limited unless a method can be found to confine these tax reductions to small and moderate-sized agricultural units (p. 383).

Study Area and Objectives

Sacramento County, the area selected for analysis, is a county that has an important agricultural sector as well as a major urban area. The county ranks twenty-third among California's fifty-eight counties in total value of agricultural products sold and eighteenth in harvested cropland area (U.S. Dep. Commerce 1972). Agriculture is diverse, as indicated by the ten leading commodities in 1975: cattle and calves, corn, milo, tomatoes, pears, wheat, rice, irrigated pasture, sugar beets, and alfalfa hay (in decreasing value of production). Harvested or bearing acreage in field, seed, fruit and nut, and vegetable crops totaled 383,755 acres in 1975. Field crops accounted for approximately 92% of this acreage, with vegetables, seeds, and fruit and nuts sharing about equally in the remaining acres. Within the field crop category, rangeland, irrigated pasture, and hay production accounted for 65.7% of the acreage (Sacramento County, California 1975).

The average farm size in Sacramento County (315 acres) is approximately 30% smaller than the statewide average; however, the average number of harvested acres per farm (149.5) exceeds the statewide average by 10%. The average size of Sacramento County farms is 19% below the nationwide average, but harvested acreage per farm is 22% above the national average. Thus, the county appears to be characterized by smaller than average livestock operations and other activities involving nonharvested acreage, but it is somewhat above the state and national average for harvested acreage per farm.[5]

Ownership concentration of harvested cropland provides a further measure for comparing counties. In California, the concentration of harvested acreage in large farms (over 2,000 acres) varies greatly among counties (from 0 to 70%). Sacramento County, with 17.9% of its harvested cropland in large farms, is well below the statewide figure of 35.6% but is above the national average of 14.3%. Of the forty-four counties that participate in the CLCA, Sacramento ranks twenty-eighth in percentage of harvested cropland in large farms. In terms of small farms (under 100 acres), Sacramento County, with 68% of its farms in this category, is below the state average of 77% but above the national average of 65% (U.S. Dep. Commerce 1972, 1973).

Although the great diversity found in California makes it difficult to define a representative county or generalize widely from the results of this analysis, we believe that Sacramento County is sufficiently representative of a substantial number of counties within the state (and elsewhere) to provide important income distributional information to policy makers. By examining the benefits to all CLCA landowners within the county, the present study seeks to overcome the deficiencies of the only previous distributional analysis of use-value assessment, which focused solely on the largest beneficiaries of the CLCA (Fellmeth)—an approach that could not evaluate the extent to which lower income landowners benefitted from the program.

The present analysis examines income distributional impacts of the CLCA over the entire population of participants in Sacramento County in terms of (*a*) proportions of benefits received by participants according to their income level, (*b*) the differential effect of CLCA benefits on income according to income category, and (*c*) differences between farmer and nonfarmer participants.

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[5] Among CLCA respondents in Sacramento County, the average size of holding of 453 acres is considerably above the county average. This is to be expected, since many smaller sized holdings are in transition to urban uses.

Methodology and Methodological Problems

Information used in this study was obtained from a mail survey of all CLCA contract holders in Sacramento County in 1973. Respondents were asked to indicate the appropriate category of net taxable family income and their tax filing status (e.g., single, married filing joint return, etc.). From this information the state and federal income tax rates were determined for each respondent. An overall response rate of more than 65% was achieved, with 50.3% usable questionnaires containing information on income. Due to a concern that the sensitive questions relating to income might cause the sample to be unrepresentative, nonrespondents were compared with respondents according to number of parcels owned, acreage owned, and benefits received from the Act. No biases that would indicate lack of representativeness of the sample were detected by any of these measures.

For each parcel under CLCA contract, the market and CLCA assessed values and total property tax rate were obtained from the Sacramento County Assessor's Office.[6] Applying the property tax rate to the difference between market and CLCA assessed values for each contracted parcel, the gross CLCA benefit was obtained. The gross benefit was multiplied by the appropriate income tax rate and the result was deducted from the gross CLCA benefit to obtain the net CLCA benefit. "Preprogram" taxable income was estimated for each respondent by subtracting the gross CLCA benefits from the indicated net taxable family income. Gini coefficients were then computed for the pre- and postprogram distribution.[7]

The treatment of the two distinct types of corporations found in California agriculture poses several problems. In the first type of corporation, ownership is similar to the typical industrial corporation with large numbers of shareholders. Agricultural endeavors may provide a small fraction of the earnings of these corporations. The other entity is the subchapter S corporation owned by a small number of individuals, typically within a single family. Ideally, a distributional analysis would seek to determine the eventual distribution of benefits to all individual holders of corporation stock—clearly a most difficult task. Bonnen apparently resolved this problem by treating corporations as individuals. For purposes of this analysis, subchapter S corporations are considered as families (the unit of measure used for the noncorporate cases). Benefits received by nonsubchapter S corporations were calculated and compared with the benefits received by all families but were not included in the income distribution calculations because of our inability to estimate total income earned by corporations.[8]

The choice of an appropriate measure for evaluating the distributional effect of a program is not clearcut. Objections can be raised to any of the possible income or wealth measures that have been used by previous researchers. In an extensive discussion, Weisbrod and Hansen proposed a combined income-net worth measure. While appealing, the problems of obtaining such information by survey, especially when added to the need for information from which to estimate tax rates, caused this approach to be discarded. Accordingly, net taxable family income was selected since it allowed accurate determination of the tax rate while providing a reasonable income measurement as a basis for the distributional analysis.

Distribution of CLCA Benefits Among All Respondents

Respondents were categorized into nine different income groups ranging from under $6,000 to over $50,000, and the net CLCA benefits received by each income group were tabulated (table 1). Results show that a large percentage of program benefits accrue to the lower income groups. The two lowest income groups, comprising 22.4% of the total sample, received only 5.0% of the net taxable postprogram income but received 20.9% of the net CLCA benefits. The next two lowest income groups ($8,001–10,000 and $10,001–13,000) received a share of net benefits (24.3%) even greater than their proportion of the population (15.5%), while receiving only 7.5% of the total income. Thus, the four lowest income groups, which received 12.5% of the net taxable income, received 45.2% of net CLCA benefits.

[6] Under California law, land must be appraised at its market value, with the assessed value being, in all instances, 25% of market value.

[7] Calculation of the Gini coefficient of income concentration is described by Miller (pp. 274–76).

[8] Attempts to obtain accurate income information from the corporate respondents were unsuccessful, most wishing not to divulge earnings. Since the corporations were few in number, we believe this treatment does not greatly distort the results.

Table 1. Pre- and Postprogram Income Distribution Among All Respondents, 1973 Survey

	Preprogram			Postprogram			
		Cumulative Percentage of			Cumulative Percentage of		
Income Range	Frequency	Sample	Income	Frequency	Sample	Income	Net Benefits
Under $6,000	36	22.4	1.6	23	14.3	2.4	13.4
6,001–8,000	12	29.6	4.3	13	22.4	5.0	20.9
8,001–10,000	10	35.8	7.2	11	29.2	7.9	31.9
10,001–13,000	17	46.3	13.5	14	37.9	12.5	45.2
13,001–16,000	17	56.8	21.3	21	50.9	21.3	54.5
16,001–20,000	22	70.4	33.7	26	67.1	34.7	67.3
20,001–25,000	15	79.6	44.4	18	78.3	46.2	82.3
25,001–50,000	20	92.0	64.0	22	91.9	66.9	94.6
Over 50,000	13	100.0	100.0	13	100.0	100.0	100.0
Gini coefficient		0.514			0.450		

Note: Distribution based on actual CLCA benefits and net taxable family income, excluding nonsubchapter S corporations.

At the other extreme, the two highest income groups ($8,001–10,000 and $10,001–13,000) rereceiving 53.8% of the income but only 17.7% of the net CLCA benefits. The three middle groups with income in the $13,001–25,000 range received benefits that were approximately in the same proportion as their income and size. They received 33.7% of the income and 37.1% of the net benefits, while comprising 40.4% of the sample.

A comparison of the preprogram to postprogram income distribution indicates that the impact of the CLCA benefits in changing overall income distribution is substantial (see table 1). Net CLCA benefits were 39.7% of the total postprogram income of the lowest income category. As a result of the benefits received by the lowest income category, the number of families in this category dropped by 36% (from thirty-six to twenty-three). Income received by the lowest 22% of the population increased as a result of CLCA participation from 1.6% to 5.0% of total income, and the share received by the lowest 30% of the population increased from approximately 4.5% to 7.9%. The Gini coefficients declined from 0.514 for the preprogram distribution to 0.450 for the postprogram distribution.

Analysis of Within-Subgroup and Between-Subgroups Results

Of the 161 noncorporate survey respondents, 92 identified their principal occupation as farmer or farm manager, 45 as unrelated to farming, 16 as retired, and 8 failed to indicate their occupation. The 61 nonfarmers and retirees accounted for 39.6% of the CLCA contract holders and 25.7% of the net CLCA benefits.

A comparison of the farmers with all other respondents ("nonfarmers") revealed that the preprogram average income of $23,357 for nonfarmers is considerably higher than the farmers' average income of $16,873.[9] In addition, the preprogram income distribution shows a considerably greater degree of inequality for the farmer subsample, as reflected in a Gini coefficient of 0.537 compared with 0.463 for the nonfarm sample (tables 2 and 3).

In terms of the distribution of benefits, it is seen (tables 2 and 3) that for both subcategories the proportion of net benefits received by the lower income groups is greater than their proportion of preprogram total income. For the farmers, the lowest 25.0% receive only 6.4% of the income but receive 20.4% of the net CLCA benefits. Lower income categories are even more favored in the nonfarmer group, with the lowest 27.9% receiving 39.0% of net CLCA benefits, while receiving only 7.7% of the total income. Although conclusions should be approached with caution because of the small number of observations in the lowest income categories, the results of this survey show that for both subgroups a relatively higher proportion of benefits are received by the low-income categories.

Changes in the distribution of income as a result of the CLCA are very different between

[9] Removal of the eight persons not indicating their occupation from the nonfarmer subsample has virtually no impact on the income distribution.

Table 2. Pre- and Postprogram Income Distribution, Farmer Subsample, 1973 Survey

	Preprogram			Postprogram			
		Cumulative Percentage of			Cumulative Percentage of		
Income Range	Frequency	Sample	Income	Frequency	Sample	Income	Net CLCA Benefits
Under $6,000	25	26.9	1.9	13	14.1	2.6	10.4
6,001–8,000	8	35.5	5.4	10	25.0	6.4	20.4
8,001–10,000	8	44.1	9.9	9	34.8	10.8	32.2
10,001–13,000	7	51.6	15.1	6	41.3	14.5	47.2
13,001–16,000	10	62.4	24.2	12	54.4	23.9	55.6
16,001–20,000	11	74.2	36.4	14	69.6	37.5	67.2
20,001–25,000	6	80.6	44.7	9	79.4	48.3	85.1
25,001–50,000	12	93.5	67.7	13	93.5	71.3	95.6
Over 50,000	6	100.0	100.0	6	100.0	100.0	100.0
Gini coefficient		0.537			0.446		

Note: Distribution based on actual CLCA benefits and net taxable family income, excluding nonsubchapter S corporations.

the two groups. For the farmer respondents, the impact of the CLCA benefits on changing overall income distribution is quite large in comparison with the nonfarmer sample. The 26.9% of the population in the lowest income category (under $6,000) for the farmer sample received only 1.9% of the income prior to the program, whereas after the program only 14.1% of the population remained in this category; yet this smaller percentage received 2.6% of total income. By contrast, although only 14.8% of the nonfarmer population was in this category before the program, 13.1% still remained after the program, and the increase in their portion of total income was from 0.9% to only 1.9%.

The differential shift in income distribution for the two subsamples is reflected in the Gini coefficients reported in tables 2 and 3. For the farmer subsample, the change in distribution is most notable, with a drop in the postprogram Gini coefficient of 0.091. For nonfarmers the decrease was only 0.018. In absolute terms, average income increased under the program by $2,934 for the farmers and only $1,666 for nonfarmers to a level of $19,807 and $25,023, respectively. Thus, the differential impact of the preprogram versus postprogram benefits for the farmer and nonfarmer groups is found to bring the two groups closer together both in terms of absolute income and the equality of income distribution. The shift in income dis-

Table 3. Pre- and Postprogram Income Distribution, Nonfarm Subsample, 1973 Survey

	Preprogram			Postprogram			
		Cumulative Percentage of			Cumulative Percentage of		
Income Range	Frequency	Sample	Income	Frequency	Sample	Income	Net CLCA Benefits
Under $6,000	9	14.8	0.9	8	13.1	1.9	22.4
6,001–8,000	3	19.7	2.3	2	16.4	2.8	22.6
8,001–10,000	1	21.3	2.9	2	19.7	4.0	32.7
10,001–13,000	8	34.4	9.3	5	27.9	7.7	39.0
13,001–16,000	7	45.9	16.2	9	42.6	16.2	51.8
16,001–20,000	9	60.7	27.0	11	60.7	29.0	67.9
20,001–25,000	9	75.4	40.8	8	73.8	40.6	72.8
25,001–50,000	8	88.5	57.9	9	88.5	59.7	91.3
Over 50,000	7	100.0	100.0	7	100.0	100.0	100.0
Gini coefficient		0.463			0.445		

Note: Distribution based on actual CLCA benefits and net taxable family income, excluding nonsubchapter S corporations.

tribution among all respondents noted earlier can be attributed almost entirely to changes in distribution within the farmer subsample.

When the results of the eleven nonsubchapter S corporations (6.4% of all respondents) were examined, it was found that only 6.5% of net CLCA benefits were received by this category. Thus, even with the inclusion of nonsubchapter S corporations, the results of our 1973 survey of Sacramento County still support the conclusion that the effect of the CLCA is highly favorable to the lower income respondents.

Concluding Comments

Historically, national income redistributive programs have encountered difficulty in achieving their goals (Lane). Farm programs, often with explicit distributional goals, have encountered similar difficulty in effecting a change in the proportion of income received by low-income farm families (Bonnen, Schultze). Given the historic difficulties of redistributional programs and the previous criticism of the distributional impacts of the CLCA (Fellmeth), it was anticipated that the present study would provide a refinement of previous research in documenting the extent of concentration of program benefits among higher income farm entities. The results of our study were contrary to those expectations. For Sacramento County, the percentage of CLCA benefits obtained by corporations is small. Among all individual and subchapter S corporate respondents, the distribution of benefits is strongly in favor of the lower income groups. Furthermore, this redistributive effect is of sufficient magnitude, particularly among farmers, to cause a substantial change in the Gini coefficient.

The present study does not, however, invalidate the Fellmeth findings with respect to absolute levels of benefits received by the largest beneficiaries of the program. Thus, public policy makers may still wish to impose size of payment, size of enrollment, or residency restrictions on CLCA participation to achieve an even more favorable income distribution. Care should be taken in generalizing the Sacramento County results to other areas, and the rather high taxable family income levels among all respondents dampen the conclusions somewhat. However, our results indicate it is incorrect to single out the CLCA as contributing to a worsening of income distribution within agriculture. To the contrary, distributional impacts of the program appear to be highly favorable to lower income farmers.

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Timber Management Decision Making under Imperfect Capital Markets

Paul A. Murphy, James C. Fortson, and James E. Bethune

Capital market imperfections seldom have been considered in the choice of financial criteria for making timber management decisions. A forest planning model for evenaged timber management is developed to evaluate criterion selection under imperfect markets. Some investment rules are shown to be equivalent to maximizing the firm's liquidation value for certain capital market conditions. Although imperfect capital markets severely limit wealth accumulation, small deviations from the optimal harvesting schedules do not severely affect the firm's value. Much concern about criterion selection would evaporate if the firm's investing and financing functions were integrated into a single process.

Key words: dynamic programming, forest investment, investment criteria, rotation age.

Assuming perfect markets in capital theory allows derivation of simple, elegant solutions to optimal intertemporal resource allocation, but no theory exists to handle capital budgeting problems when imperfect capital markets are encountered. Under a perfect capital market, adopting a strategy that maximizes the criterion "net present value of the firm" is equivalent to maximizing the economic welfare of the firm's owners. In imperfect markets this equivalence does not necessarily hold, and the problem of determining an acceptable financial decision-making criterion arises.[1]

Both net present value and internal rate of return have been proposed as criteria for making decisions in forest management, but relating criterion selection to imperfect capital markets has been rarely considered. This study is a first attempt to incorporate imperfect capital markets into a forest planning model using dynamic programming.

Past Work

Usually the primary investment goal is to maximize utility from consumption or to maximize wealth (Hirshleifer). Wealth maximization implies that accumulation is the ultimate goal of economic activity; utility maximization implies that consumption is the ultimate goal. Under perfect capital market conditions, maximizing net present value results in maximum utility because consumption and investment decisions can be made independently (Hirshleifer). However, in imperfect capital markets, investment and consumption decisions, in general, must be made jointly. Joint consideration requires a utility function, and since utility is difficult to quantify, utility maximization is of more theoretical than practical usefulness.

Most financial studies in forestry have dealt with wealth maximization, specifically with criterion selection for determining optimal rotation length. Gaffney, Goundry, and Bentley and Teeguarden stated that the return to the fixed factor should be maximized in rotation length selection. If the firm's land base is fixed, net present value is the correct criterion. If capital is fixed, internal rate of return is correct. Lippman proved that, with certain restrictions, investing in the project with the highest internal rate of return maximizes cash on hand at the end of a finite planning period. His restrictions allow neither consumption nor borrowing during the planning period.

Fortson investigated how adopting either net present value or internal rate of return affected optimal harvesting schedule and resultant flow of cash and wood from an industrial forest property. He postulated that inter-

Paul A. Murphy is a resource analyst with the Southern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, New Orleans, Louisiana; James C. Fortson is an associate professor in the School of Forest Resources, University of Georgia; and James E. Bethune is the chairman of the Department of Natural Resources, University of Connecticut.

[1] As used here, a criterion is a mathematical transformation on the revenue and cost stream of an investment. An investment rule utilizes the computed value of a criterion to determine the acceptability of an investment.

nal rate of return is the preferable criterion if the firm is expanding, whereas net present value is preferable if the firm is of constant size.

Capital rationing is a common market imperfection that has been studied in the capital budgeting literature. Weingartner used mathematical programming for selecting investment projects that are subject to capital rationing and other restrictions.

Maximizing return to a fixed factor as a guide to criterion selection is inadequate. Land and capital can be fixed simultaneously. Often neither is fixed. Furthermore, use of net present value implies that a perfect capital market exists in which funds can be lent or borrowed at the discount rate. Use of internal rate of return implies no capital market transactions, an infinite supply of forest land with the same productivity, and continued expansion of the enterprise (Bentley and Teeguarden). Hirshleifer pointed out the use of the internal rate of return implies infinite future value of the firm, hardly a reasonable assumption.

These two situations—a perfect capital market and no capital market—are extremes not encountered in practice. Either the amount of money that can be borrowed or lent is restricted in some way, or a multiplicity of lending and borrowing rates occur. What is the appropriate criterion for these situations? Our objective is to provide insight into this question.

Scope and Plan of Study

To judge the suitability of investment criteria, the concept of a globally optimal policy—the strategy that maximizes liquidation value at every point in time—is first developed.

Liquidation value of the enterprise is defined as the market value of the firm's assets at a particular time. Liquidation value in this sense is a measure of wealth. If a strategy maximizes wealth at every point in time, it is independent of the planning horizon. Independence is tested by ascertaining whether the optimal strategy varies with changes in length of the planning horizon.

Finite planning horizons are used in this study. Independence is determined by examining the optimal strategy for every planning horizon up to a specified maximum. The maximum time horizon used here is 100 years. If they do not vary, it is assumed that the optimal strategy is independent of the planning horizon and is a globally optimal policy.

Maximizing liquidation value is a constrained extremum problem falling within the province of mathematical programming. Dynamic programming is especially suitable because, in the course of obtaining an overall solution, the strategy for maximizing liquidation value in each intervening year of the planning period is also determined. In this study, dynamic programming models are developed for scheduling timber harvest and determining optimum size of the land base for an evenaged forest. The solutions generated by each model are analyzed to determine whether they are globally optimal and to investigate effects of adopting nonoptimal strategies in imperfect markets.

Assumptions are that the firm sells pulpwood on the open market and that any amount of bare land can be bought or sold for a constant price per acre. All land is managed identically. Regeneration costs and annual costs are constant per unit of land area. Harvested areas are successfully regenerated in the year of harvest. The only restrictions imposed on the investment decisions are those inherent in the choice of a finite planning period and in the imperfect market conditions examined. No constraints are imposed on wood flow.

The effect of choice of investment rule is investigated for (*a*) a forest enterprise operating under a perfect capital market and with a constant land base. Results for that case are then compared with those from (*b*) no capital market, variable land base; (*c*) absolute debt limit, variable land base; (*d*) internal generation of funds, variable land base; (*e*) maximum debt-equity ratio, variable land base; and (*f*) divergent lending and borrowing rates, variable land base. Of these, only the dynamic programming formulations of cases (*a*), (*b*), and (*f*) are presented here. Some implications of the results from other imperfect capital market cases are discussed. These examples are an intermediate step between assumption of a perfect capital market and the uncertainty that pervades capital budgeting in practice.

Procedures and Results

Perfect Capital Market, Constant Land Base

Liquidation value is maximized for a forest enterprise practicing evenage management on

one acre of forest land and operating under a perfect capital market. Annual costs are not included in the formulation, as they are considered fixed and not subject to managerial control. The firm's opportunities are to grow timber or to lend money at the current interest rate i. The initial endowment is $\$g_0(t_0)$. If the firm grows timber, it incurs a land cost of $\$b$ and a regeneration cost of $\$c$. If the initial endowment is insufficient to pay expenses, the balance can be borrowed at interest rate i compounded continuously. The expected yield in cords in t_j years is $y(t_j)$ at stumpage value per cord p.[2] Only one initial stocking level is considered. Liquidation value after one rotation is the value of the stumpage, the endowment, and accumulated interest:

$$(1) \quad py(t_1) + b + g_0(t_0)e^{it_1} - be^{it_1} - ce^{it_1}.$$

Let

$$(2) \quad g_k(t_k) = py(t_k) + b - ce^{it_k} - be^{it_k}, \qquad k = 1, \ldots, n,$$

then equation (1) can be rewritten as

$$(3) \quad g(t_1) + g_0(t_0)e^{it_1}.$$

Assuming that $g_0(t_0) = 0$, the maximum liquidation value at the end of the first rotation is

$$(4) \quad f_1(t) = \max_{\{t_1\}}\{g_1(t_1)\}.$$

The alternatives at the end of the first rotation are invest all the endowment at the external rate or invest in another timber rotation and lend the balance of the endowment at the market rate of interest. If the total endowment is invested at the external rate, the newly acquired revenue is

$$(5) \quad g_1(t_1)e^{it_2}.$$

If a second rotation is undertaken, the net revenue received at its end is

$$(6) \quad py(t_2) + b - ce^{it_2} - be^{it_2} + g_1(t_1)e^{it_2},$$

or

$$(7) \quad g_2(t_2) + g_1(t_1)e^{it_2}.$$

The maximum liquidation value for two rotations at the end of t years is the maximum of equations (5) and (7), or

$$(8) \quad f_2(t) = \max_{\{t_1,\, t_2\}} \{g_2(t_2) + g_1(t_1)e^{it_2},\ g_1(t_1)e^{it_2}\}.$$

[2] The form of this function is determined from Bennett and Clutter for planted slash pine, site index 80 (base age 25), 500 trees per acre.

Equation (8) is used to derive a recurrence relation between $g_1(t_1)$ and $g_2(t_2)$. No matter what the allocation t_2, the remaining years in the planning period $t - t_2$ must be optimally allocated to the first rotation. The optimal allocation of $t - t_2$ to the first rotation is $f_1(t - t_2$. Therefore,

$$(9) \quad f_2(t) = \max_{\{t_2\}} \{g_2(t_2) + f(t - t_2)e^{it_2}, f_1(t - t_2)e^{it_2}\}.$$

Dropping the assumption that $g_0(t_0) = 0$, let $g_0(t_0)$ be any constant and let

$$(10) \quad f_0(t) = \max \{g_0(t_0)\}.$$

We want to find the maximum liquidation value of the firm at the end of a finite planning period of t_{max} years, where n is the maximum number of rotations. The general recurrence relation is

$$(11) \quad f_k(t) = \max_{\{t_k\}} \{g_k(t_k) + f_{k-1}(t - t_k)e^{it_k}, f_{k-1}(t - t_k)e^{it_k}\}, \ k = 1, \ldots, n$$

subject to the restriction

$$(12) \quad 0 \le t_0 + t_1 + \ldots + t_n \le t_{max}.$$

Equation (11) is solved using the following values: $y(t_j) = e^{5.46096 - 28.15438/t_j}$, $i = 0.06$, $t_{max} =$ 100 years, $p = \$8$, $c = \$20$, $b = \$171.91$, and $f_0(t) = \$171.91$. The initial endowment $f_0(t)$ equals the land value, as it is assumed the firm owns the land at the beginning of the planning period.

The number of rotations for a problem is not usually known in advance, but an optimal solution is insured by setting the number of rotations considered larger than the number expected in the solution. Seven rotations are specified in the example.

The optimal strategy for a planning period of 100 years is to manage a sequence of five eighteen-year rotations, then sell the land in the ninetieth year, and invest the proceeds at the market rate of interest (table 1). For planning periods of less than 100 years, the general optimal strategy is to grow timber for the maximum number of eighteen-year rotations that can be subsumed by the planning period, sell the land immediately after harvesting the last rotation, and invest all proceeds at the market rate of interest for the rest of the planning period. This strategy holds for any planning period and thus is globally optimal.

The globally optimal policy can be inter-

Table 1. Optimal Strategy for the Perfect Capital Market, Constant Scale Problem

Rotation Number	Rotational Length[a] (Years)	Terminal Year in Planning Period	Liquidation Value of the Firm ($)
1	18	18	507
2	18	36	1,494
3	18	54	4,399
4	18	72	12,955
5	18	90	38,150
6	10z	100	69,513
7	—	—	—

[a] The letter "z" following the rotation length indicates that all the endowment is invested at the market rate of interest.

preted as managing the sequence of eighteen-year rotations that can be subsumed by the planning period, then selling the land, and investing the endowment at the interest rate for the remainder of the planning period.

A globally optimal policy is thus shown to exist. Any investment rule that leads to its adoption must be the best rule for the perfect capital market. Because

$$t_1 + t_2 + \ldots + t_n = t_{max}, \tag{13}$$

this problem can be changed to a net present value one by multiplying by the constant $e^{-it_{max}}$. Since this constant has no effect on the optimal policy, maximizing net present value is equivalent to maximizing liquidation value and is, therefore, the best investment rule.

The market value of the land is equal to the present worth of all future incomes expected to emanate from it. The effect of variations in the land's market price on the optimal policy can be observed by changing land value to $100 per acre. The resulting optimal strategy (table 2) then differs from that selected when land value equals the capitalized value of future income flows (table 1). Moreover, a change in planning period length results in a changed optimal strategy. Hence, there is no globally optimal policy. Conversely, if the market value exceeds net discounted value, timber growing would be uneconomic. The land would be sold, and the proceeds would be lent at the market rate of interest.

Table 2. Optimal Strategy for the Constant Scale, Perfect Capital Market Problem with a Reduced Land Value

Stage Number	Policy[a] (Years)	Year in Planning Period	Liquidation Value of the Firm ($)
1	18	18	435
2	18	36	1,422
3	18	54	4,327
4	19	73	13,683
5	20	93	45,591
6	7z	100	69,389

[a] If the letter "z" follows the policy number, all the endowment is invested at the market rate of interest.

This result implies that, at least for the production opportunities and capital markets examined here, liquidation value of the assets must equal the present worth of their future income flows for a globally optimal policy to exist. By being contained in the market value of the asset, cash flows subsequent to the planning horizon are introduced implicitly. This implied introduction of infinite flows makes the optimal strategy independent of time, so that it is unaffected by planning period length.

Constant Returns to Scale, No Capital Market

We now turn to the case in which returns to scale are constant but there is no capital market. With no capital market, timber management must be financed entirely from the firm's endowment and internal rate of return is the correct criterion, as shown by Boulding, Bentley and Teeguarden, and Lippman. Therefore, the maximization of internal rate of return is investigated first to insure that it is amenable to solution.

In addition to the variables defined for the first case, let x_j be acres owned during the jth rotation, and a be annual costs per acre. Because timber management must be financed solely from the firm's endowment, the amount of land that can be financed for the first rotation is determined by dividing the endowment by the per acre cost for a rotation of t_1 years, or

$$x_1 = f_0(t)/[b + c + at_1], \tag{14}$$

where $f_0(t)$ is a constant. The net revenue received by the firm at the end of the first rotation is

$$x_1[py(t_1) + b]. \tag{15}$$

The amount of land that can be financed for the second rotation is the revenue from the first rotation divided by the per acre cost for the second:

$$x_2 = x_1[py(t_1) + b]/[b + c + at_2], \tag{16}$$

or, in general,

$$x_{k+1} = x_k[py(t_k) + b]/[b + c + at_{k+1}], \quad k = 1, \ldots, n-1. \tag{17}$$

If a perfect capital market exists, the net revenue received by the firm from timber growing at the end of the kth rotation would be

$$h_k(t_k,x_k) = x_k[py(t_k) - ce^{it_k} + b - be^{it_k} - a\int_0^{tk} e^{iu}\,du]. \tag{18}$$

It follows that liquidation value of the firm at the end of a planning period, t_{max} years in length, with n rotations would be

$$L(t,x) = h_1(t_1,x_1)e^{i(t_{max}-t_1)} + h_2(t_2,x_2)e^{i(t_{max}-t_1-t_2)} + \ldots + h_n(t_n,x_n)e^{i(t_{max}-t_1-\ldots-t_n)}. \tag{19}$$

To maximize internal rate of return, equation (19) first must be set equal to zero. Moreover, the problem is further constrained by equations (14) and (17) and consequently is a constrained extremum problem:

$$\max i \tag{20}$$

subject to the restrictions

$$x_1 = f_0(t)/[b + c + at_1], \tag{21}$$

$$L(t,x) = 0, \tag{22}$$

and

$$x_{k+1} = x_k[py(t_k) + b]/[b + c + at_{k+1}]. \tag{23}$$

Maximizing internal rate of return subject to these restrictions is a nonlinear programming problem. No method of solution is found.

The problem can be simplified considerably by excluding annual costs. With regeneration cost of \$$c$ per acre and land purchase price of \$$b$ per acre, the maximum amount of land that can be financed for the first rotation is

$$x_1 = f_0(t)/(b + c). \tag{24}$$

The value of the firm after the first rotation is

$$h_1(t_1) = x_1[py(t_1) + b]. \tag{25}$$

The amount of land that can be financed for the second rotation is

$$x_2 = h_1(t_1)/[b + c]. \tag{26}$$

Because there are no transaction costs, it is assumed that all land is sold at the end of a rotation and repurchased for the next rotation, thereby simplifying the formulation. The net worth at the end of the second rotation is

$$h_2(t_2) = x_2[py(t_2) + b] = f_0(t)[py(t_1) + b][py(t_2) + b](b + c)^{-2} \tag{27}$$

Let

$$g_k(t_k) = [py(t_k) + b]/[b + c], \quad k = 2, \ldots, n. \tag{28}$$

Therefore, the firm's value after the kth rotation is

$$f_0(t)g_1(t_1)g_2(t_2) \ldots g_k(t_k). \tag{29}$$

Liquidation value at the end of a finite planning period is

$$H(t) = f_0(t)g_1(t_1) \ldots g_n(t_n), \tag{30}$$

subject to

$$t_1 + t_2 + \ldots + t_n \leq t_{max}. \tag{31}$$

During intermediate rotations, all cash proceeds are immediately expended for the subsequent rotation; thus, the only net cash flows are initial and terminal amounts. Discounted proceeds and outlays are equated by

$$f_0(t) = f_0(t)g_1(t_1) \ldots g_n(t_n)e^{-i(t_1+\ldots+t_n)} = 0. \tag{32}$$

Solving for i,

$$i = \ln[g_1(t_1)g_2(t_2) \ldots g_n(t_n)]/[t_1 + t_2 + \ldots + t_n]. \tag{33}$$

Because the rotation lengths must sum to t_{max},

$$i = \ln[g_1(t_1)g_2(t_2) \ldots g_n(t_n)]/t_{max}. \tag{34}$$

Because $1/t_{max}$ is constant, maximizing the expression

$$\ln[g_1(t_1)g_2(t_2) \ldots g_n(t_n)] \tag{35}$$

maximizes i. Moreover, values of t_j, $j = 1, \ldots, n$, that maximize equation (30) are invariant under the logarithmic transformation. Therefore, maximizing internal rate of return is equivalent to maximizing liquidation value. The development of the dynamic programming recursion formula is straightforward. Equation (30) is maximized subject to restriction (31).

The optimal allocation to the first rotation is

$$f_1(t) = \max_{\{t_1\}} \{g_1(t_1)f_0(t - t_1)\}, \tag{36}$$

where $f_0(t - t_1)$ is a constant. The optimal allocation to the first two rotations is

$$(37) \quad f_2(t) = \max_{\{t_1,t_2\}} \{g_2(t_2)g_1(t_1)f_0(t - t_1)\}.$$

Applying the principal of optimality, no matter what the allocation t_2 is, allocation of the remaining time to the first rotation is optimal. Equation (37) in general becomes

$$(38) \quad f_k(t) = \max_{\{t_k\}}\{g_k(t_k)f_{k-1}(t - t_k)\}, \quad k = 1, \ldots, n.$$

Table 3 contains a solution for equation (38), where $y(t_k) = e^{5.4098-28.15438/t_j}$, $p = \$8$, $b = \$25$, $c = \$20$, $f_0(t) = \$1{,}000$, $t_{max} = 100$ years, and $n = 8$.

The results show liquidation value maximized when individual rotation lengths are nearly equal. For example, the optimal strategy for a planning period of ninety-five years is (14, 13, 14, 14, 14, 13, 13, 0). However, because rotation lengths vary with change in planning period length, a globally optimal policy does not exist.

The remaining models to be explored are more realistic than either the perfect capital market or no capital market case. They represent conditions frequently encountered in practice. Further algebraic formulations and dynamic programming solutions are omitted except in the last example.

Absolute Debt Limit

Imposition of a capital market imperfection limiting the amount of borrowing to $20,000 is studied. As in the no capital market case, land base is treated as a variable. Stumpage price varies inversely with increasing size of land base. This situation may exist where there is only one large primary processing plant, such as a pulpmill. Since there is only a single market, and stumpage price is a residual, the price declines as transport distance to the processing facility increases.

Table 3. Optimal Strategy for the Constant Returns to Scale, No Capital Market Problem

Stage Number	Policy (Years)	Year in Planning Period	Liquidation Value of the Firm ($)
1	14	14	6,155
2	15	29	42,834
3	15	44	298,070
4	14	58	1,834,730
5	14	72	11,293,429
6	14	86	69,515,133
7	14	100	427,890,760
8	—	—	—

The optimal strategy adopted shows that for the first forty-nine years the firm's expansion is limited by the limit on debt. However, with each rotation the firm generates more capital to finance the next rotation. By the end of the third rotation, the firm generates enough capital so that debt limit no longer restricts expansion of the land base. Subsequent land base sizes are optimal for the rotation length selected.

The problem is then resolved with the debt limit restriction lifted to ascertain how severely the debt limit reduces liquidation value. Optimal policies with and without the debt limit are similar, but imposition of a debt limit reduces liquidation value 78% and thus adversely affects wealth accumulation. The optimal strategy changes slightly with changed length of planning horizon, so no globally optimal policy is demonstrated.

Internal Generation of Funds

In this formulation, investments are limited to those permitted by funds generated within the timber management operation. The problem is a special case of the debt limit problem in which debt is restricted to zero. With debt financing prohibited, the capital market imperfection operates more restrictively than in the debt limit problem. Not until the eighty-first year are sufficient funds generated to deactivate the capital market restriction. Eliminating debt financing causes a 95% drop in liquidation value as compared with a perfect capital market solution. As in the previous solution, changes in the planning horizon result in slight changes in the optimum rotation lengths; therefore, no globally optimal policy is determined.

Maximum Debt-Equity Ratio

In this formulation, the amount borrowed is limited by a maximum allowable ratio of debt to equity. Such a limitation arises in several ways. The firm may adopt such a policy to protect the value of its stock, or lenders may impose such a limitation to insure loan recovery in the event of dissolution of the firm. The debt assumed is the discounted costs of the

rotation minus the current endowment. The equity is the market value of land holdings. For this solution, the maximum debt-equity ratio is set at 0.5. Permissible debt increases as the endowment increases. Timber management operations are limited by the debt-equity restriction for the first sixty-one years. After the fourth rotation, the restriction is no longer active. This restriction reduces liquidation value by 93%.

Differing Lending and Borrowing Rates

We now turn to the last and most realistic model. Usually, lending and borrowing rates of interest differ. We assume that although there is a divergence of rates, the firm can lend at the rate i_1 and borrow at i_2 without restriction as to amount; also, $i_2 > i_1$.

When both lending and borrowing occur within the same rotation, the model becomes a dynamic programming problem with three state variables. No suitable method was found to solve the three state variable case, so a simplification is employed to make the problem amenable to solution. As in the no capital market case, the source of difficulty is the inclusion of annual cost. Consequently, annual costs are deleted. The following equation is the value of a timber rotation t_k years in length and x_k acres in size:

$$(39)\quad g_k(t_k,x_k,i_k) = x_k\,p(x_k)y(t_k) + b - ce^{i_k t_k} - be^{i_k t_k};\ i_k = i_1,\ i_2.$$

The interest rate is now a variable.

The dynamic programming problem contains three state variables, but x_k and i_k may be determined as follows. The firm, if possible, will try to make the size of the land base optimal. Let x_{k2}^* be the root of the equation.

$$(40)\quad \partial g_k(t_k, x_k, i_2)/\partial x_k = 0.$$

Since the second derivative of equation (39) with respect to x_k is negative, the function is a maximum at x_{k2}^*. Hence, the optimal scale size for a fixed t_k would be x_{k2}^*. The optimal scale size for a fixed t_k would be x_{k2}^* when money is borrowed.

If

$$(41)\quad x_{k2}^*(b + c) \geq f_{k-1}(t-t_k),$$

money is borrowed and $x_k = x_{k2}^*$. However, if

$$(42)\quad x_{k2}^*(b + c) \geq f_{k-1}(t - t_k),$$

then the rotation can be financed entirely from internally generated funds. Let x_{k1}^* be the root of the equation

$$(43)\quad \partial g_k(t_k,x_k,i_1)/\partial x_k = 0.$$

If

$$(44)\quad x_{k1}^*(b + c) \leq f_{k-1}(t - t_k),$$

then scale size is not restricted by the endowment and $x_k = x_{k1}^*$. If inequality (44) is violated, then $x_k = x_{k1}^{**}$, where

$$(45)\quad x_{k1}^{**} = f_{k-1}(t - t_k)/(b + c).$$

The dynamic programming recursion formula becomes

$$(46)\quad f_k(t) = \max\{g_k(t_k, x_k, i_k) + f_{k-1}(t-t_k)e^{i_k t_k}, f_{k-1}(t-t_k)e^{i_1 t_k}\},\quad k = 1, \ldots, n.$$

Values of x_k and i_k are determined at each stage by fixing the value of t_k. The first expression in the recurrence relation is the value of investing in timber management. The second expression signifies that all the endowment is lent at the interest rate i_1.

Table 4 shows the optimal strategy of the differing lending and borrowing rates problem, where $y(t_k) = e^{5.46098-28.16438/t_k}$, $p(x_k) = \$(8 - 0.03\,x_k^{1/2})$, $t_{max} = 100$ years, $b = 25$, $c = \$20$, $i_2 = 0.10$, $i_1 = 0.06$, and $f_0(t - t_1) = 0$ (initial endowment).

For the first thirty-two years of the planning period, the firm finances timber management by borrowing. At the end of the second rotation, sufficient money is generated so that the firm is restricted by neither the divergent interest rates nor the size of the endowment. A globally optimal policy does not exist because a variation in planning period length changes the optimal strategy. With a planning period of ninety-five years, the optimal rotation lengths become t_{95} = (16, 16, 19, 19, 20, 5*, 0). The asterisk by the 5 indicates that all the endowment is invested externally for the last five years of the planning period.

How much does the gap in interest rates affect the liquidation value? Table 5 shows the optimal strategy for the case in which the interest rates are identical, $i_1 = i_2 = 0.06$. No other changes are made in the problem. The liquidation value in table 5 for the last year in the planning period represents the maximum value attainable. The results indicate that the divergent interest rates cost the firm about 64% of its potential value. If the divergence was less, this loss would be smaller.

Table 4. Optimal Strategy for the Different Lending and Borrowing Rates Problem with Decreasing Returns to Scale

Stage	Policy (Years)	Land (Acres)	Restriction Code[a]	Year in Planning Period	Liquidation Value of the Firm ($)
1	16	4,789	1	16	201,327
2	16	4,789	1	32	1,198,504
3	19	16,820	2	51	5,497,188
4	18	16,709	2	69	17,783,010
5	17	16,488	2	86	50,742,260
6	14	14,854	2	100	118,393,100
7	—	—	—	—	—

[a] If money is borrowed, the code is 1; if money is lent and the scale size is unrestricted, the code is 2.

The effect of following a nonoptimal policy can also be assessed. Assuming no divergence in interest rates, what would be the result of the firm managing a sequence of nineteen-year rotations, all 16,820 acres in size, and then investing the resulting endowment in year ninety-five of the planning period for the remaining five years? The liquidation value of this strategy would be $330,799,918. Thus, the percentage loss following this nonoptimal policy is minuscule.

Discussion and Conclusions

Extension of the forest planning model to include determining not only optimal rotation length but also optimal size of the forest land base poses no conceptual difficulty. A change in rotation length produces a fairly large modification in the forest land base, indicating that the optimal size may be sensitive to changes in other variables.

An important finding is that liquidation value is relatively insensitive to small deviations from the optimal strategy. Consequently, the forest manager can vary harvesting schedules somewhat without significantly affecting liquidation value.

Comparison of liquidation values obtained when constraints such as debt limit are imposed or not imposed on the models show that the presence of market imperfections limits the firm's wealth accumulation. The severity of this limitation depends on the type of imperfection and the degree by which it deviates from the perfect capital market.

Equivalence of maximum liquidation value with other investment rules has been demonstrated for the perfect capital market case and the no capital market case. Equivalence can also be shown for the remaining cases in a similar manner.

The maximum liquidation value problem may be transformed to one of maximum net present value by multiplying by the constant e^{-it} for the following problems: absolute debt limit, internal generation of funds, and maximum debt-equity ratio. This transformation is suitable for these problems because the sum of the optimal rotation lengths in all cases is equal to the length of the finite planning horizon. Because the transformation is a constant, it has no effect on optimal strategy.

The different lending and borrowing rates problem is more complex. A simple transformation does not exist because the effective rates of interest are determined in the course

Table 5. Optimal Strategy for the Decreasing Returns to Scale Problems with No Capital Market Restrictions and Annual Costs Excluded

Stage	Policy (Years)	Land (Acres)	Restriction Code[a]	Year in Planning Period	Liquidation Value of the Firm ($)
1	19	16,820	0	19	1,749,743
2	19	16,820	0	38	7,220,783
3	19	16,820	0	57	24,327,453
4	19	16,820	0	76	77,816,103
5	21	16,783	0	97	276,342,658
6	3	0	9	100	330,842,185
7	—	—	—	—	—

[a] If investment is made in timber management, the code is 0; if all the endowment is invested at the external rate, the code is 9.

of solving the problem and cannot be determined a priori. Nevertheless, this problem too may be transformed to a net present value problem with no effect on the optimal strategy. The solution for the maximum net present value problem is identical to the one for maximum liquidation value.

A globally optimal policy is demonstrated to exist only for the perfect capital market case. The distinguishing features of this problem are the presence of a perfect capital market and a pricing of the firm's assets, particularly land, that reflects the assets' income-producing potentials. Thus, these income flows are implicitly introduced into the problem.

The equivalence of the market value and the capitalized value of an asset becomes more unlikely under imperfect capital markets. For example, in the different lending and borrowing rates problem, the present value of an asset's income stream is calculated using an interest rate that depends upon the amount of the firm's accumulated wealth. Thus, the prospect of the market price of land coinciding with its value to a firm is unlikely. The conditions necessary for the existence of a globally optimal policy are, therefore, quite demanding.

Because use of the globally optimal policy to find a "best" criterion is limited in application, forest managers are still faced with the problem of criterion selection. Much concern about the choice of financial criteria, however, would evaporate if the financing functions and investment functions are integrated into a single decision-making process—usually using mathematical programming. The cost of capital then becomes part of the analysis, and opportunity costs can be evaluated using the dual variables of the mathematical programming model. Capital budgeting models found in the literature (e.g., Weingartner) and the simple models formulated in this study demonstrate how the financing and investment functions can be integrated. This integration represents the next logical step in the evolution of timber management planning.

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Portfolio Adjustments: An Application to Rural Banking

Lindon J. Robison and Peter J. Barry

A general method is provided for evaluating how an expected-utility-maximizing choice is changed in response to factors shifting the mean-variance (EV) efficient set and changes in the decision maker's level of risk aversion. Substitution and income effects under uncertainty are defined, related to those existing under certainty, and analyzed graphically and in a quadratic programming model of a rural bank. The bank application includes risk and liquidity components and indicates that the magnitude of the portfolio response may not be trivial. Evidence is also provided indicating the consistency between bank behavior and the EV decision criterion.

Key words: expected utility, portfolio theory, risk, rural banking.

Numerous studies in decision making under risk have focused primarily on generating information needed to identify an initial expected-utility-maximizing choice from a mean-variance (EV) efficient set. Such studies have sought better ways to order portfolios into efficient and inefficient sets and better ways to measure probability distributions and utility functions (Dillon). However, much less attention has been given to evaluating the response of the expected-utility-maximizing choice to changes in decision parameters that shift the EV set (Tobin, Cass and Stiglitz, Levy, Adler, Royama and Hamada). Because this response may be significant, there is a need to develop a conceptual framework and empirical methods for predicting equilibrium adjustments under uncertainty.

This paper provides a general method for evaluating how an expected-utility-maximizing choice is changed in response to factors shifting the EV set and changes in the decision maker's level of risk aversion. The following sections define appropriate measures of risk aversion and shifts in the EV set caused by changes in the probability distribution of returns on risky assets, changes in returns on safe assets, and changes in initial wealth. The substitution and income effects under uncertainty are defined, related to those existing under certainty, and analyzed both graphically and in a quadratic programming model of a representative rural bank. The bank example demonstrates that the magnitude of the portfolio response may not be trivial and should be the subject of further empirical analyses. The paper concludes with a review of various approaches for evaluating the consistency between bank behavior and the EV decision criterion.

Lindon J. Robison is an agricultural economist with the Economic Research Service, U.S. Department of Agriculture, and Peter J. Barry is an associate professor of agricultural economics at the Texas Agricultural Experiment Station, Texas A&M University.

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Risk Aversion Measures

Consider a decision maker choosing among risky alternatives with outcomes expressed by probability distributions. Assume further that his utility function for wealth $U(Y)$ reflects diminishing marginal utility for increases in wealth. This condition describes a risk averter, an individual who requires an expected return on a risky asset in excess of the returns on a safe asset in order to be indifferent toward investment in the two assets. This difference—a risk premium—decreases as the investor becomes less risk averse. The degree of risk aversion is exhibited in two measures formulated independently by Arrow and Pratt to allow interpersonal comparisons of risk aversion at particular wealth levels: $R_a(Y) = -U''(Y)/U'(Y)$ = absolute risk aversion, and $R_r(Y) = -YU''(Y)/U'(Y)$ = relative risk aversion.

Each measure implies different responses of risk aversion to changing levels of wealth. Consider the following results for a decision maker who can allocate his wealth between a risky and a safe asset. If the amount of wealth invested in the risky asset increases (decreases) with wealth, the investor has decreasing (increasing) absolute risk aversion. If the proportion of wealth invested in the risky asset increases (decreases) with wealth, the investor has decreasing (increasing) relative risk aversion.

In the analysis to follow the direction of portfolio adjustments on the EV frontier is related to measures of increasing, constant, or decreasing absolute risk aversion ($R'_a(Y) \gtreqless 0$). Empirical observation by Arrow and by others strongly supports an assumption of decreasing absolute risk aversion. Hence, the absolute measures permit a fairly general yet definitive treatment of portfolio responses. Empirical evidence on relative risk aversion is less definitive. Arrow, for example, provides a theoretical argument with some empirical support for increasing relative risk aversion. More recent studies (Cohn et al., Friend and Blume) provide evidence supporting both decreasing and constant relative risk aversion.

Shifts in EV Sets

To begin the discussion of shifts in EV sets, the following definitions are offered. A negative (positive), nonparallel shift in the EV set occurs if lines drawn tangent to the EV sets at points of equal variance form a smaller (larger) angle of inclination with the abscissa, the axis measuring expected wealth. A parallel shift in the EV set occurs if lines drawn tangent to the EV sets at points of equal variance form the same angle of inclination with the abscissa.

Nonparallel shifts are caused by changes in expected returns or variance of a risky asset(s) and by changes in returns of a safe asset(s). Shifts to the right are illustrated in figure 1. The nonparallel shifts induced by changes in the distribution of risky assets do not change the point of intersection of the EV frontier with the axis measuring expected wealth. In contrast, nonparallel shifts induced by changes in returns of a safe asset do change the point of intersection.

Suppose, for example, that the expected return on a risky asset increases. Since this increase permits a higher level of expected terminal wealth with the same variance for all portfolios holding the risky asset, the new EV frontier resulting from the increased returns lies to the right of the initial frontier, and the slope of the tangent line at the point of equal variance declines. A negative, nonparallel shift to the right is also caused by a reduction in the variance of a risky asset. The reduction in asset variance implies a higher level of expected terminal wealth for the same level of portfolio variance or, alternatively, a lower level of variance for the same level of terminal wealth. In a similar fashion, positive, nonparallel shifts to the left of the EV frontier result from increases in the variance or decreases in the expected returns on risky assets. Finally, increases in the expected return on a safe asset cause positive, nonparallel shifts to the right of the EV frontier, while decreases in the return on a safe asset produce negative shifts to the left.

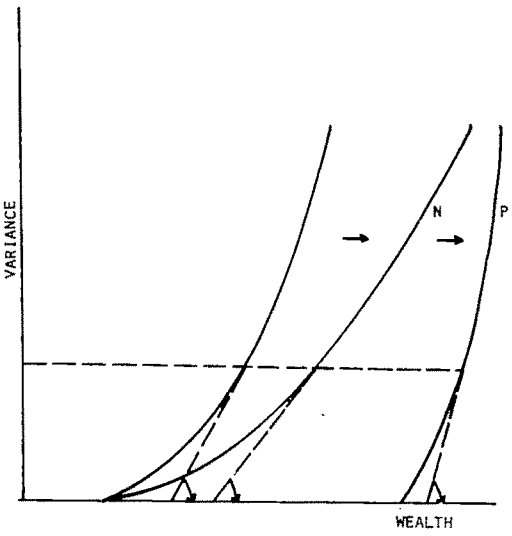


Figure 1. Negative (*N*) and positive (*P*) nonparallel shifts

Parallel shifts in the EV frontier are caused by changes in the decision maker's initial wealth. Adding risk-free wealth increases expected terminal wealth by equal amounts for each portfolio in the original EV set, leaving their variances unaffected. Hence, the EV frontier shifts right with tangent lines at points of equal variance exhibiting the same slope.

The Income Effect

Under conditions of certainty, a change in demand for an asset resulting from an increase

in real income with prices held constant is defined as an income effect. Under uncertainty, however, prices of assets are random variables, and to identify the income effect their distributions are assumed to remain constant as risk-free wealth increases. Thus, the income effect under uncertainty is the change in demand for an asset resulting from an increase in risk-free wealth while holding probability distributions constant and is expressed by a parallel shift in the EV frontier.

Continuing the analogy under certainty, an increased, decreased, or constant demand for an asset resulting from an increase in risk-free wealth identifies an asset as normal, inferior, or neutral, respectively. Under uncertainty, if the equilibrium variance on the new EV frontier has increased, decreased, or remained constant following a parallel shift to the right, then the demand for the risky assets has changed accordingly, and they may be considered as normal, inferior, or neutral assets, respectively.

The kind of income effect occurring under conditions of uncertainty is related to measures of absolute risk aversion by the following theorem (Cass and Stiglitz): if there are two assets, one risky and one safe, total purchases of the risky asset increase, remain constant, or decrease with increase in initial wealth as absolute risk aversion decreases, remains constant, or increases.

The separation property defined by Tobin permits extension of the analysis from a two-asset to a general (n-asset) model, provided one of the assets is risk free. Tobin shows that the desired combination of risky assets along an EV set is independent of the amount invested in the safe asset. Therefore, all relevant portfolio choices along an EV set can be provided by varying the amount invested in a risk-free asset and the amount invested in a fixed combination of the risky assets. This separation property permits the utility-maximizing choice from an EV set to be considered as a choice between one risky asset and one risk-free asset.

Hence, the Cass and Stiglitz theorem implies that, for choices among $n - 1$ risky assets and one safe asset from an EV set, the income effect for the $n - 1$ risky assets is positive, zero, or negative as absolute risk aversion decreases, remains constant, or increases. Corollary 1 can now be derived: if there are n assets with at least one risk free and if the expected-utility-maximizing choice occurs from an EV set, then an increase in risk-free wealth increases, leaves unchanged, or decreases the equilibrium slope on the new EV frontier for decreasing, constant, or increasing absolute risk aversion, respectively.

To prove this corollary, recall that an increase in risk-free wealth produces a parallel shift to the right in the EV set. By definition, the slopes at points of equal variance on parallel EV curves are the same and can vary only by changing the purchases of risky assets. The Cass and Stiglitz theorem together with Tobin's separation property require that for increases in risk-free wealth purchases of the $n - 1$ risky assets increase, remain constant, or decrease for decreasing, constant, or increasing absolute risk aversion, respectively. Therefore, the equilibrium slope on the new EV set increases, remains constant, or decreases, respectively, for decreasing, constant, or increasing absolute risk aversion.

These results indicate that risky assets are normal goods for investors with decreasing absolute risk aversion, neutral goods for investors with constant absolute risk aversion, and inferior goods for investors with increasing absolute risk aversion. In a similar fashion, if an increase in risk-free wealth yields no additional purchases of risky assets, then holdings of safe assets must increase. Hence, safe assets are normal goods for investors with constant or increasing absolute risk aversion and may be normal, inferior, or neutral goods for investors with decreasing absolute risk aversion.

The Substitution Effect

Under conditions of certainty, the substitution effect is the change in demand for an asset resulting from a change in relative prices after compensating the decision maker for a change in real income. Under uncertainty, the substitution effect is defined as the change in quantity demanded resulting from a change in the probability distribution of prices after compensating the decision maker for a change in risk-free income.

The substitution effect for adjustment in EV efficient portfolios is illustrated in figure 2. Let the initial equilibrium occur at point A on EV frontier 1. Since the exact shape of the indifference curve causing the equilibrium at point A is uniquely determined by each decision maker's utility function, one can approximate

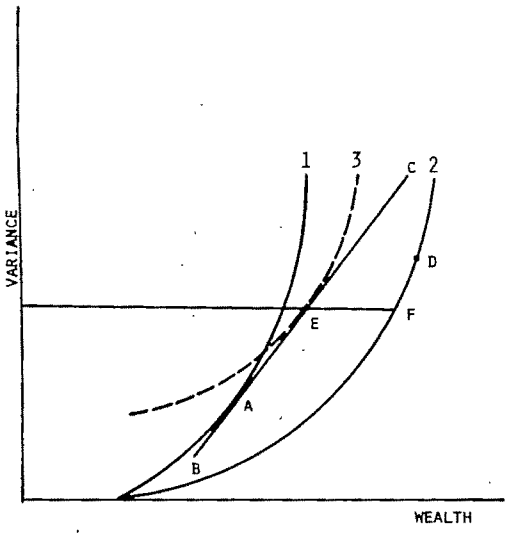


Figure 2. Income and substitution effects

the indifference curve by the straight line BC drawn tangent to point A. Let the EV frontier exhibit a negative, nonparallel shift to the right caused by a reduced variance or by an increased expected return on a risky asset. Further, let the decision maker's new equilibrium occur at point D on EV frontier 2. To identify the substitution effect, the decision maker is compensated for his increase in real income by a parallel shift of EV frontier 2 to the left until a new tangency occurs at point E between the compensated EV frontier 3 and straight line BC, which approximates the decision maker's initial indifference curve. The substitution effect is the difference in the quantity of assets held in portfolios A and E. The income effect explains changes in the quantity of assets arising from the movement from portfolio E to D. The portfolios E and F have the same variance and thus the same amount of risky assets. The income effect for risky assets between E and F is therefore zero and can only be nonzero if the slope on the new EV frontier changes. Hence, the change in the amount of risky assets is the same whether the adjustment occurs from A to E or from A to F.

Any change in the quantity of risky assets that occurs while holding the equilibrium slope of the EV frontier constant is due entirely to the substitution effect. Any change in the quantity of risky assets that occurs when the slope changes is due entirely to the income effect. For safe assets, the income effect expressed by parallel shifts in the EV frontier while holding the equilibrium slope constant is not zero but is equal to the difference of the increase in expected wealth and the change in the holdings of risky assets.

How the equilibrium slope on the new EV frontier changes from the initial equilibrium depends on the decision maker's measure of absolute risk aversion. The results are expressed in corollary 2: if the expected-utility-maximizing choice occurs from an EV set and the indifference curve is approximated by a linear tangent to the EV set, then for any shift to the right (left) the equilibrium slope increases (decreases), remains constant, or decreases (increases) as there is decreasing, constant, or increasing absolute risk aversion.

To prove corollary 2, recall that for nonparallel shifts the substitution effect is identified as the movement between the tangency of the linear approximation of the indifference curve with the original EV frontier and its tangency with the compensated EV frontier. The slopes at these two tangency points are equal. Since the compensated EV frontier and the new EV frontier are parallel, movements from one to the other involve adjustments to parallel shifts. From corollary 1 it is known that, for parallel shifts to the right, the purchase of risky assets and hence the equilibrium slope increases, remains constant, or decreases for decreasing, constant, or increasing absolute risk aversion, respectively. Hence, the result of corollary 2 is proved.

The adjustments in equilibrium slopes to changes in risk aversion and shifts in EV frontiers have the following effects on portfolio wealth and variance. Increases in initial wealth as expressed by parallel shifts cause equilibrium variance to increase, remain constant, or decrease as there is decreasing, constant, or increasing absolute risk aversion. Expected wealth increases for decreasing or constant absolute risk aversion and may increase or decrease for increasing absolute risk aversion depending on the magnitude of the income effect.

For negative, nonparallel shifts to the right, expected portfolio wealth and variance increase for decreasing or constant absolute risk aversion. This result follows from the earlier definitions that indicate that a portfolio on the new EV frontier with the same variance has a smaller slope and only by increasing the variance can a slope be obtained that equals or exceeds the slope of the initial portfolio.

Similarly, for positive, nonparallel shifts to the right, the equilibrium variance decreases for constant or increasing absolute risk aver-

sion. Again, the definitions imply that for positive shifts a portfolio on the new EV frontier with the same variance has a greater slope and only by decreasing the variance can a slope be obtained that is less than or equal to the slope of the initial portfolio. Analogous responses can be derived for leftward shifts in the EV frontier.

To this point, the analyses of income and substitution effects associated with shifts in EV sets have been expressed in terms of their effects on equilibrium slopes and on total wealth and variance of the portfolios. Extending the adjustment theory to evaluate holdings of individual assets requires further mathematical development and is treated in detail by Robison. It can be shown, for example, that an individual asset's substitution effect is directly related to changes in its expected return and inversely related to changes in its variance. Increases in both an asset's expected return and its variance would therefore tend to be offsetting. More complicated relationships exist for substitution effects caused by changes in covariances and by changes in expected returns and variances of other assets.

Portfolio Adjustments and Rural Banking

The portfolio adjustment process is illustrated in a risk programming analysis of a rural bank that typically allocates part of its loans to financing agriculture. Rural banks are generally small in size and often experience special liquidity problems arising from seasonal flows of loans and deposits. They also experience rather high risks in agricultural lending due primarily to variability in farmers' incomes and limited opportunities for asset diversification. These conditions have prompted much concern with the ability of rural banks to cope with these risk and liquidity problems and still offer adequate loan services to their customers (Federal Reserve Board of Governors 1975). One approach to studying these problems is through the use of bank models that include risk and liquidity components. Including these components permits more thorough and accurate evaluation of a bank's portfolio responses to changes in loan risks, liquidity needs, costs of funds, and other factors.

A representative model bank for southeastern Texas is used as a basis for formulating the risk programming model. Assets in its balance sheet total nearly $25 million with equity capital of $1.2 million, a loan to deposit ratio of 0.55, and a loan to capital ratio of 10.42. The model is developed for relatively easy adaptation to banks of different size, type, structure, location, and other such characteristics. The general properties of the model are summarized below, while additional information on bank theorems, model structure, and data is found in Robison.

The mean-variance criterion assumes that the decision maker's expectations are formulated in terms of normal distributions that are fully specified by means and variances or that his utility function is quadratic, reflecting preferences only toward means and variance of expected returns. We assume that the banker's expectations on wealth are normally distributed, hence restricting his expected-utility-maximizing choice to an EV set. The banker's ordinal utility function is then approximated for a given level of utility by the negative exponential $U(Y) = 1 - e^{-aY}$, where $a > 0$. The negative exponential implies linear indifference curves between means and variances that are consistent with the linearity assumed in deriving the substitution effect. Freund has shown, for example, that maximizing the expected value of the negative exponential integrated over a normal density function is equivalent to maximizing $E[U(Y)] = W - a\sigma^2/2$. Multiplying through by $\lambda = 1/a$ yields $E[U(Y)] = \lambda W - \sigma^2/2$. Parameter λ identifies the optimal EV choice by expressing the desired trade-off or equilibrium slope between variance (σ^2) and expected wealth (W) for the given level of utility.[1]

The initial EV set is derived with a quadratic program specified to identify bank portfolios with minimum variance for alternative levels of expected wealth for a three-month period. The bank's decision variables include choices in lending and in purchasing securities, acquiring deposits, borrowing, and paying taxes and dividends. Net earnings from these activities add to bank wealth. Risk is introduced as variance-covariance entries for

[1] Strictly interpreted, the negative exponential utility function as expressed above with linear mean-variance indifference curves implies constant absolute risk aversion. Allowing λ to vary with different levels of expected utility produces a set of nonparallel linear indifference curves that approximate the actual indifference curves only in the neighborhood of the tangency with the EV frontier. Extending the nonparallel linear indifference curves much beyond this neighborhood eventually leads to their intersection, thereby violating the indifference feature. However, this analysis assumes that variations in λ do model the income effect for investors with different degrees of risk aversion and that any intersection of indifference curves does not occur near the tangency point.

expected returns on loans and for liquidity risk, reflecting linkages between the stochastic demand for cash from deposit variability and capital gains and losses arising from liquidation of one-year and two-year bonds prior to maturity. Three-month bonds have no liquidity risk and are specified as safe assets with zero variance. Annual expected rates of return, variances, and covariances for these investments are reported in table 1.[2]

One EV efficient solution is selected as the bank's utility-maximizing choice in order to serve as the basis for rerunning the quadratic program to observe portfolio adjustments to changes in deposit costs, expected rates of return, variances, loan-deposit feedback rates, and risk aversion. Holding λ constant as other parameters are changed produces portfolio adjustments reflecting the substitution effect for risky assets. Allowing λ to vary introduces the income effect.

Quadratic programming results for changes in these parameters are reported in table 2 for activities entering the EV efficient solutions. Column 1 reports parameter values and activity levels for the initial solution. Column 2 indicates model results for increasing deposit costs, equivalent to a decline in risk-free wealth. A decline in risk-free wealth causes a parallel EV shift to the left, while holding λ constant implies a zero income effect and constant risk aversion. Constant absolute risk aversion implies that risky assets are neutral goods that do not change with wealth. The model's purchases of risky assets and equilibrium variance remain constant. However, expected terminal wealth decreases with the decrease in wealth.

Column 3 combines increasing deposit costs with a declining slope. Decreasing λ for a parallel shift to the left implies decreasing absolute risk aversion, a decline in the purchase of risky assets, and a decrease in equilibrium variance and expected terminal wealth. In turn, purchases of safe assets increase.

Column 4 introduces an increased rate of return on agricultural loans resulting in a negative, nonparallel EV shift to the right. Holding λ constant requires that both variance and expected terminal wealth increase in order to achieve the new equilibrium. The new equilibrium contains increased purchases of agricultural loans and reduced purchases of safe assets.

Column 5 reflects a reduction in the deposit feedback on real estate loans causing, in effect, a reduced rate of return on that asset. The result is a positive, nonparallel EV shift to the left. As expected, results respond in a manner opposite to those of column 4. Holding λ constant requires a decrease in equilibrium variance and expected terminal wealth. The purchase of real estate loans declines as does that of agricultural loans—a complementary asset.[3]

[2] Expected net returns on loans are estimated from the 1970 through 1972 quarterly *Functional Cost Analysis* reports for a rural bank in central Texas (Federal Reserve Bank of Dallas). Variances and covariances reflecting default risk and variations in lending costs are calculated as deviations from a regression of net loan returns with time as the independent variable. Lending incurs no liquidity risk, since sales of loans prior to maturity are not permitted.

Estimates of expected net returns on securities are obtained from historical data published in the *Federal Reserve Bulletin* (Federal Reserve Board of Governors 1970–72). Securities are assumed to be coupon bonds bought at par with fixed quarterly interest payments. Risk on securities is attributed solely to their likelihood of sale prior to maturity to meet stochastic demands for cash at values that may vary with changes in market interest rates. This liquidity risk is reflected by variances and covariances of expected returns on securities that are derived statistically from a time series of quarterly bond values from 1970 through 1972 and weighted by an assumed probability of liquidation. Finally, covariances among expected returns on loans and securities are assumed to be zero.

[3] Under certainty two assets are complementary if an increase in returns on one increases the demand for the other. Under risk and for investors with constant or decreasing absolute risk aver-

Table 1. Annual Expected Net Returns and Variances and Covariances for Bank Investments

	Agricultural Loan	Real Estate Loan	Installment Loan	1-Year Bond	2-Year Bond	3-Month Bond
				%		
Expected net returns	6.92	6.20	4.88	5.30	5.86	4.66
Variances and covariances						
Agricultural loan	0.400	−0.038	0.134	0	0	0
Real estate loan	−0.038	0.328	0.356	0	0	0
Installment loan	0.134	0.356	0.468	0	0	0
1-year bond	0	0	0	0.228	0.024	0
2-year bond	0	0	0	0.024	0.324	0
3-month bond	0	0	0	0	0	0

Table 2. Results of Quadratic Programming Model of a Commercial Bank for Selected Parameter Changes

	Model					
Parameters	1	2	3	4	5	6
Equilibrium slope (λ)	5,654	5,654	5,500	5,500	5,500	5,500
Deposit cost (%)	4.80	5.00	5.00	5.00	5.00	5.00
Rate of return—agr. loan (%)	6.92	6.92	6.92	6.96	6.96	6.96
Feedback—real estate loan	0.2	0.2	0.2	0.2	0.05	0.05
Variance—agr. loan (%)	0.4	0.4	0.4	0.4	0.4	0.5
Quarterly results ($1,000)						
Expected wealth	1,280.2	1,280.1	1,279.4	1,279.8	1,279.2	1,278.9
Variance	180,288.7	180,288.7	176,511.0	178,545.9	175,975.8	174,227.4
Purchase risky assets						
Real estate loan	340.1	340.1	340.1	340.1	126.9	115.2
Agricultural loan	626.7	626.7	398.4	522.1	501.9	400.6
Purchase safe assets						
3-month bond	3,290.0	3,290.0	3,488.3	3,380.8	3,557.6	3,656.8
Ending cash	7,648.8	7,648.6	7,789.2	7,713.0	7,873.5	7,946.5

Column 6 reflects results of an increased variance on agricultural loans generating a positive, nonparallel EV shift to the left. As in column 5, a positive, nonparallel EV shift to the left while holding λ constant requires that equilibrium variance and expected wealth both decline. The solution contains reduced purchases of risky assets and increased purchases of safe assets.

EV Analysis and Bank Behavior

The predictive ability of portfolio adjustment theory presumes, of course, that the decision maker—the rural banker, in this case—behaves according to the assumptions underlying the theory. These assumptions include those of ordering, continuity, and independence, which underlie expected utility theory (Dillon), the distinction between risky and safe assets, and the responses of absolute risk aversion to changing wealth. Moreover, utility estimation using the mean-variance criterion also requires the normality or quadratic utility assumptions discussed earlier.

The restrictiveness of the mean-variance assumptions has been seriously criticized (Borch, Feldstein). Assuming normality may be inappropriate for many investment situations, although in this analysis assuming normality and linear indifference curves to approximate the expected-utility-maximizing choice from the EV set is judged to be less restrictive than assuming quadratic utility. Quadratic utility functions must clearly be used with care because they eventually exhibit declining total utility as wealth increases and they imply portfolio adjustments consistent with increasing absolute risk aversion, results that seem inconsistent with commonly observed risk behavior. Still, the severity of these mean-variance restrictions is not fully resolved. Tsiang, for example, has demonstrated the general applicability of the EV criterion as long as the portfolio risk, expressed by the ratio of variance to mean expectations, is small relative to the expected value of returns. This general applicability of the EV criterion together with its mathematical convenience have contributed greatly to its extensive use in empirical research.

Nonetheless, despite the extensive use, there is still need to evaluate whether or not decision behavior appears consistent with the EV criterion. Consider, for example, the effect on a rural bank's portfolio of increased risk on agricultural loans, a commonly observed condition in the early 1970s (Barry and Fraser). Riskier agricultural loans imply greater difficulties in debt servicing and greater likelihood of loan default with both conditions reflected in EV analysis by increased variance on agricultural loans. Portfolio adjustment theory together with risk programming results suggest reduced holdings of agricultural loans as well as other complementary assets. Confirming this result in terms of actual bank behavior involves the use of one or more approaches to empirical observation of bankers' preferences, performance, or

sion, two assets are complementary if an increase in the expected returns on one increases the demand for the other or if an increase in the variance of one decreases the demand for the other.

both. Several of these approaches to empirical observation are briefly reviewed.

Consider first an evaluation of bankers' responses to loan risk through review of periodic banker surveys of credit conditions and financial outlook. These surveys are designed in part to elicit the lender's expectations on credit responses to changes in a number of decision parameters. Presumably, these expectations are used in managing the bank's portfolio and thus are reflected in actual decision making. Numerous lender surveys are currently used, and many include questions on the lender's response to changing loan risks. An example is a survey conducted by the American Bankers Association and made available to the U.S. Department of Agriculture for the 1975 *Agricultural Finance Outlook*. Bankers were asked to identify their responses if farm lending were to become more risky. Possible responses included reduction in the volume of farm lending and increases in interest rates, security requirements, and degree of supervision of farm loans.

Only the volume response is specified in the portfolio adjustment theory. However, it seems reasonable to expect that lenders may utilize one or more of the other risk responses instead of or in addition to the volume response. Indeed, only 38 of 119 lenders responding to the question indicated a likely reduction in farm lending, while 24 even indicated an increase in farm lending. However, cross-checking of answers for other risk responses confirms their use as substitute responses. As an example, of the 81 bankers who would not reduce farm lending, 48 reported that they would increase interest rates on farm loans as a risk response. In addition, 108 bankers indicated they would increase security requirements on farm loans, and 111 indicated an increase in loan supervision. Hence, these results appear generally consistent with the results of portfolio adjustment theory, although a wider range of risk responses was permitted in the survey.

A second approach to empirical testing consists of a simulated borrowing and interview approach to measure the bankers' credit responses to changes in loan risk. Barry and Willmann use this approach in evaluating lender responses to alternative levels of forward contracting by crop producers. They observe that the contracting strategy most preferred by the sample of lenders generates about 17% more total credit and about 53% more crop credit than the lenders' least preferred strategy. This observation is consistent with the portfolio adjustment indicated here in that increased risk on agricultural loans would reduce their level in the bank's portfolio of risky assets.

A third approach that could be used to observe bank behavior is analysis of historical financial data in order to relate the responses of various bank portfolio holdings to changes in expected risk, returns, and wealth. While balance sheet and income data are available for individual U.S. banks (Federal Reserve Board of Governors 1976), the data still only indicate the jointly occurring effects of banker's decisions and numerous other factors that influence the portfolio composition. Hence, the data only provide limited insight on actual bank decisions. It would be difficult, in the case of rural banks, to identify and measure the joint effects of changes in interest rates, the money supply, general price levels, deposit composition, reserve and other legal requirements, bank charter and management, loan demand and lending competition, and risk responses by borrowers, all of which interact with changing loan risk to explain observed portfolio adjustments. Nonetheless, developing procedures for measuring these joint effects appears to be a fruitful area for further research.

Another approach to observing behavioral preferences is through the derivation of expected utility functions for individual rural bankers. These utility functions would identify the properties of an expected distribution of returns that are relevant to the banker and would help value the risk parameter together with its response to changing wealth. Increasing experience has been gained in deriving expected utility functions. Empirical evidence in the case of farmers, for example, indicates that expected utility theory likely explains farmer behavior more accurately than profit maximization (Lin, Dean, and Moore). However, little evidence can be found on the derivation of utility functions for rural bankers or on utility responses over time to changes in decision parameters.

There is also concern with the appropriateness of distinguishing between risky and safe assets. However, this distinction in commercial banking is in accordance with commonly used practices. Crosse and Hempel review the

various approaches to assessing the adequacy of bank capital and indicate the various risk classes of bank assets. Risk-free assets are normally considered to be cash balances, short-term government securities, federal funds sold, and other assets of high quality and short maturity. While these assets may experience small degrees of market risk, they are generally considered to be virtually riskless. Other bank assets are considered risky with the risk expressed by variances and covariances as outlined earlier.

Concluding Comments

The portfolio adjustment framework developed in this paper extends the firm's equilibrium analysis to conditions of uncertainty. The distinction of income and substitution effects associated with shifts in EV frontiers and changes in risk aversion provides a stochastic counterpart to predicting equilibrium adjustments under conditions of certainty. This extension should enhance the predictive ability of expected utility theory assuming, of course, that the decision maker behaves according to the premises of the theory. While several approaches to behavioral observation are reviewed, it is clearly an area for further empirical analysis.

In terms of methodology, the portfolio adjustment framework explicitly introduces risk as a behavioral influence and broadens the kinds of sensitivity analyses that can be used in evaluating equilibrium adjustments. The rural bank example demonstrates the need to model risk and liquidity components for more complete evaluation of the bank's responses to factors causing changes in its risks, liquidity, and profitability. Indeed, a number of current policy issues in rural banking may significantly affect bank risk and liquidity—government guarantees of farm loans, secondary markets for farm loans, changes in bank borrowing privileges, adoption of variable interest rates, and interest-bearing demand deposits. However, the portfolio adjustment framework also adds complexity to problem identification, model specification, data needs, and empirical verification. In the bank example, careful attention would be needed to properly identify and measure the effects of each policy issue on the distribution of returns for risky assets, changes in returns on safe assets, and changes in wealth, together with their effects on risk aversion. These remain as challenging tasks.

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Measurement of Capacity Depreciation Based on Engineering Data

John B. Penson, Jr., Dean W. Hughes, and Glenn L. Nelson

The widely used estimates of annual capacity depreciation for selected types of farm producer capital published by the USDA rest on the assumption that the amount of capital consumed annually equals a constant fraction of the existing capital stocks. This study demonstrates, through the use of agricultural engineering data, that the productive capacity of farm tractors deteriorates in a concave rather than the convex pattern suggested by present USDA estimates. The implications for studies estimating aggregate production functions based on factor shares or farm investment demand equations are discussed. Finally, recommendations for change to selected sector economic accounts are made.

Key words: capacity depreciation, embodied technical progress, physical deterioration, real productive value, vintage.

Studies that have estimated aggregate farm production functions based on factor shares or have tested hypotheses related to the aggregate investment behavior of farm production sector participants generally utilize the capital stock and depreciation data series published by the U.S. Department of Agriculture (1975a, b). These studies require an accurate measure of the annual depreciation of the productive capacity of farm capital and net additions to this capacity if they are to avoid inconsistent parameter estimates. An accurate measure of capacity depreciation is also important to public acceptance of the USDA's widely followed net farm income series (1975b). Their estimate of annual depreciation, defined as that "estimated outlay, in current prices, which would be required if farmers were to replace the plant and equipment used up during the year," is an important component of the farm production expenses data series used to residually estimate net farm income (1969, p. 10). Finally, the relevance of the USDA's estimate of net investment in farm plant and equipment as an indicator of current farm business expansion requires an accurate measure of capacity depreciation (1975b). Thus, it is of considerable importance that these capital stock and depreciation data series reflect as closely as possible the actual losses in the productive capacity of farm capital.

Many researchers may not be aware that these data series are approximated by a procedure that assumes that the amount of capital consumed during production is equal to a constant fraction of the existing capital stock. This assumption suggests, for example, that the greatest single annual loss in the productive capacity of a farm tractor resulting from physical deterioration is realized in its first full year of use, the second greatest annual loss in its productive capacity in its second full year of use, etc. The adoption of this approximation procedure, according to Ott, Ott, and Yoo, is normally defended on the grounds that "capital is utilized more intensively and therefore consumed more rapidly during the early part of its service than during the latter part" (p. 112). Yet, is this assumption realistic for producer goods such as farm tractors, planters, and other farm production machinery whose annual use is limited by the biological nature of farm production and by existing plant size? In addition, what is the effect of embodied technical progress associated with new producer goods on the productive capacity of the existing capital stock? While this approxima-

John B. Penson, Jr., is an assistant professor and Dean W. Hughes is a graduate assistant in the Department of Agricultural Economics, Texas A&M University; and Glenn L. Nelson is an assistant professor in the Department of Agricultural Economics, Purdue University.

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tion procedure may be convenient in many respects, a review of literature provides little empirical evidence to support it.

This study illustrates the potential measurement error associated with the present procedures used by the USDA to approximate the capacity depreciation of farm capital. Initially, the capacity depreciation pattern implied by the USDA procedures and those suggested recently by Coen are examined. Information on postponed repairs and maintenance, accumulated use, and downtime from a recent agricultural engineering survey is then used to measure a capacity depreciation pattern for tractors purchased during 1948–74. The capital stocks and flows suggested by this pattern are then compared with those published for farm tractors by the USDA. Finally, the implications of these findings for further research are discussed.

Alternative Approximation Procedures

The existing capital stock and capital flows such as depreciation that account for changes in this stock between accounting dates can be valued in three different ways: current market value, book value, and productive value. Aside from capital sales or transfers to other sectors, the current market value of the existing stock of capital declines as economic depreciation, or loss in value, occurs during the year. Similarly, the book value of the existing stock of capital declines as tax depreciation is taken. The productive value of the existing stock of capital, on the other hand, is given by the present value of the flow of productive services it provides over the services lives of the different vintages of capital on farms.[1] Thus, when expressed in constant prices, the real productive value of the existing capital stock of farm tractors declines as physical deterioration occurs.

If firms behave as neoclassical investment theory suggests, their annual capital expenditures are influenced by the current productive capacity of their existing capital stock, while the level of firm output depends on the flow of productive services provided by capital, other things being constant. Thus, studies of aggregate production functions or investment behavior must relate to the real productive value of capital. The wisdom of using present USDA approximations of capital stocks and flows or those proposed recently by Coen in these studies must therefore depend on how accurately these data series reflect changes in the productive capacity of farm capital.

Procedure Used by the USDA

The *Balance Sheet for the Farming Sector* reports an estimate of the current market value of the existing stock of farm machinery and motor vehicles deflated by its own implicit price deflator (USDA 1975a). The unpublished estimate for the existing stock of farm tractors valued in 1967 prices is given by[2]

$$(1) \qquad K_t = (1 - 0.5\delta)I_{t-1} + (1 - \delta)K_{t-1},$$

where K_t is the current market value of the existing stock of farm tractors at the beginning of the year expressed in 1967 prices, while I_{t-1} is capital expenditures for farm tractors in the previous year, also expressed in 1967 prices (USDA 1971, p. 3). The value of δ chosen is that which reduces the original value of capital expenditures by 95% at the end of their assumed service life, implying a 5% salvage value (USDA 1969, p. 10). The USDA estimate of annual depreciation (D_t) for farm tractors published in *Farm Income Statistics* is equal, when expressed in 1967 prices, to

$$(2) \qquad D_t = 0.5\delta I_t + \delta K_t,$$

such that

[1] The current market value of farm tractors can differ from their productive value. While this phenomenon is typically observed in markets for used consumer goods such as automobiles, it seems somewhat paradoxical that a farm operator maximizing his expected utility would sell a producer good such as a farm tractor for less than its remaining productive value to the firm. Yet several hypotheses can be advanced as to why the current market price in secondary machinery markets can be less than its productive value to the firm. For example, a systematic negative bias is incurred if used tractor prices, particularly for those tractors traded in during the early stages of their service life after any warranties have expired, are used to value all tractors of identical size, technology, and age still on farms. This bias results from these tractors likely having a lower productive value than those retained on farms because they have either been used more than average or have not received normal repairs and maintenance. A second hypothesis is that the risk-averse farm operator assigns a greater weight to the likelihood of acquiring a tractor with less than average remaining productive value in secondary markets than he would to the likelihood of acquiring a tractor with greater than average remaining productive value. Thus, he discounts the price he would have been willing to pay if he had perfect knowledge of the tractor's remaining productive value. Finally, the farm operator may encounter less favorable financing arrangements with respect to the length of loan, the downpayment required, and interest rate charged on loans to purchase used machinery than available for loans to finance new machinery purchases, thereby depressing used tractor prices.

[2] The issue of accidental damage is ignored for the moment. This topic and the effects of downtime are treated in a later section.

$$N_t = K_{t+1} - K_t = I_t - D_t, \tag{3}$$

where the value of K_t is given by equation (1), while N_t represents annual net investment in farm tractors expressed in 1967 prices.

The principal source of embodied technical progress affecting the capacity of farm tractors during 1948–74 has been their increasing horsepower.[3] Since the USDA's implicit price deflator is weighted to account for prices paid for multiple size and type classes of farm tractors, the value for I_t used in equation (1) appears to adequately reflect the quality of farm tractors purchased in year t. The procedures used to approximate K_t and D_t given by equations (1) and (2) would suggest that the productive capacity of a farm tractor decays geometrically over its service life. While the depreciation pattern implied by this procedure may yield realistic estimates of economic depreciation, one would intuitively expect losses in the productive value of a farm tractor resulting from physical deterioration to be relatively small in the early stages of its service life. Due to a lack of evidence put forth by the USDA in support of its geometric decay capacity depreciation pattern for farm tractors, the advisability of using D_t as a measure of replacement investment or K_t as a measure of the real productive value of existing capital in aggregate investment behavior studies is open to question. The use of D_t when accounting for capital services in aggregate farm production functions based on factor shares must also be reconsidered.

Procedures Proposed by Coen

Based on the work of Solow, Coen recently examined several alternative capacity depreciation patterns for equipment and structures in the manufacturing sector. These patterns purportedly reflect the effects of alternative distributions of physical deterioration and embodied technical progress on the productive capacity of existing capital.

Coen's approximation procedures suggest that the real productive value of the existing stock of farm tractors according to the jth capacity depreciation pattern is given by

$$K_{jt} = \sum_{i=1}^{\infty} \left(1 - \sum_{k=1}^{i} d_{jk}\right) I_{t-i}, \tag{4}$$

such that the remaining fraction of the original productive capacity of farm tractors in the mth year after their original purchase is given by

$$1 - \sum_{i=1}^{m} d_{ji} = \left[\frac{1 - \sum_{i=1}^{m} h_{ji}}{(1+g)^m}\right]. \tag{5}$$

The h_{ji} weights reflect the fraction of the original productive capacity of farm tractors lost due to physical deterioration during the ith year after their original purchase according to the jth capacity depreciation pattern. This approximation of the existing capital stock suggests that the productive capacity of farm tractors approaches zero as the value of $\sum_{i=1}^{n} h_{ji}$ approaches one, where n denotes the end of the service life. The existing capital stock is reduced further according to the Solow-Coen aggregation theorem by the rate of embodied technical progress (g) associated with new farm tractors. This suggests that the productive capacity of the existing stock of farm tractors at the beginning of the year declines if new farm tractors are more efficient, other things being constant. Clearly, the productive capacity of the stock of farm tractors at the beginning of the year remains unchanged in this instance.[4]

Rather than assume that capacity depreciation is a constant fraction of the existing capital stock, Coen approximates replacement investment in the current year (R_t), assuming $d_{j0} = 0$, by

$$R_{jt} = \sum_{i=1}^{\infty} d_{ji} I_{t-1}, \tag{6}$$

where the d_{ji} weights are identical to those assigned to the deflated capital expenditure flows (I_t) in equation (4).[5] The real productive

[3] Other changes in technology include increased use of hydraulics, four-wheel drive, and tractor cabs. The authors are unaware of data on the effects of these innovations on the productive capacity of farm tractors. To the extent that these and other omitted technical improvements have increased the productive capacity of tractors and are not adequately reflected in the USDA's unpublished implicit price deflator, the estimate of I_t will be understated.

[4] The Solow-Coen aggregation theorem employs a sliding-scale procedure to account for technological obsolescence in the existing capital stock. Using this approach, previous vintages of farm tractors are discounted further by the current increase in efficiency units associated with new farm tractors. Two problems exist with this procedure. Initially, one could not compare the real productive values associated with the existing capital stock in 1970, for example, with that presently associated with the current capital stock. Further, the argument that the real productive value of existing tractors has declined simply because of an increase in the efficiency associated with new farm tractors has little intuitive appeal.

[5] The Solow-Coen approximation of replacement investment goes beyond the traditional concept of measuring capital used up

value of current net investment (N_t) is therefore given by

$$N_{jt} = K_{jt+1} - K_{jt} = I_t - R_{jt}. \tag{7}$$

The alternative paths taken by the capacity depreciation patterns examined by Coen are merely assumed to capture the effects of physical deterioration and technological obsolescence on the productive capacity of existing capital. Those patterns studied are (*a*) an infinite geometric decay pattern (GD-INF) that extends over an infinite time horizon, where $d_i = \phi(1 - \phi)^{i-1}$ and $\phi = 2/n$, (*b*) a finite geometric decay pattern (GD-FIN) that is truncated at the end of the assumed service life of the farm tractor, (*c*) a sum-of-the-years-digits pattern (SYD), where $d_i = (n + 1 - i) \Big/ \sum_{i=1}^{n} i$ for $i = 1, \ldots, n$, (*d*) a "one-hoss shay" pattern (OHS), where $d_i = 0$ for $i = 1, \ldots, n - 1$ and $d_n = 1$, and (*e*) a straight-line pattern (SL), where $d_i = 1/n$ for $i = 1, \ldots, n$. The fraction of the original productive capacity lost annually over the service life of the farm tractor implied by each of the above patterns is illustrated in figure 1.

The researcher adopting Coen's approximation procedures is faced with *j* net investment series that, in turn, necessitate testing *j* sets of hypotheses related to the aggregate investment behavior of farm production sector participants. Coen implies that the "right" pattern is that which yields the net investment regression with the lowest standard error of the estimate. In addition, several questions arise regarding the implications of those capacity depreciation patterns examined. The OHS capacity depreciation pattern, for example, assumes that annual repairs and maintenance restore the productive capacity of a farm tractor to its original level, that no repairs and maintenance are postponed in the latter years of its service life, and that the rate of embodied technical progress in farm tractors is equal to zero. The remaining patterns also suggest an unrealistic decline in the productive capacity of farm tractors and other farm production machinery over their service life. That the productive capacity of a farm tractor falls as fast or faster in the early years of its service life than it does in its latter years seems highly questionable. While the capacity depreciation patterns examined by Coen certainly define the upper and lower limits of study, they do not represent a realistic spectrum of possibilities. Surprisingly omitted from study to date has been the triangular area between the SL and OHS patterns in figure 1, which has the most intuitive appeal.

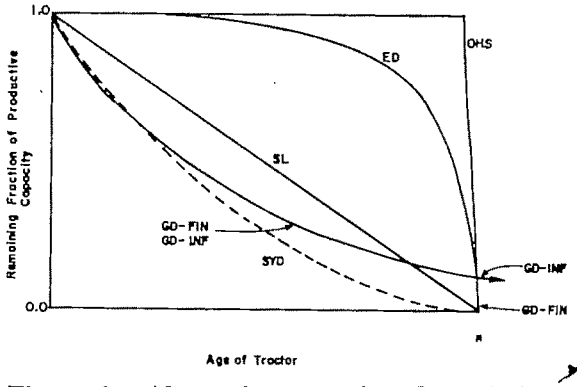


Figure 1. Alternative capacity depreciation patterns

Direct Measurement Using Engineering Data

Rather than assume one or more capacity depreciation patterns, one can instead utilize available engineering data on annual rates of physical deterioration and embodied technical progress to estimate the real productive value of capital stocks and flows; that is, engineering data can be used to estimate a pattern of d_i that, in turn, can be used to measure the real productive value of the existing stock of farm tractors and to partition net and replacement investment. As Griliches suggests, "we need to know the 'right' measure of capital in practice and how much difference it actually makes" (p. 205).

Proposed Measurement Procedure.

Based on a modification of Solow's original aggregation theorem, an alternative to equation (4) is proposed that allows the researcher to account for the specific influences that physical deterioration and embodied technical progress have upon the productive capacity of the existing stock of farm tractors. The real productive value of the existing stock of farm tractors is given by

$$K_t = \sum_{k=1}^{\infty}(1 - \sum_{i=1}^{k} h_i)I_{t-k}, \tag{8}$$

during current production or "keeping capital intact" by including technological obsolescence as well. Because of this, use of R_{jt} when estimating aggregate farm production functions based on factor shares results in measurement error, since R_{jt} measures more than just current capital consumption.

where we assume, as did Griliches, that I_t reflects the embodied technical progress (g) for tractors purchased in year t. As $\sum_{i=1}^{k} h_i$ approaches one, the remaining fraction of the original productive capacity of farm tractors purchased in year $t - k$ approaches zero. While some farm tractors may remain on farms beyond this point and have a positive salvage value, they will "fall out" of this measure of the real productive value of the existing stock.

Assuming for the moment that data are available to estimate a set of h_i weights for tractors, the procedure for measuring the real productive value of the existing stock of farm tractors given by equation (8) is preferred over that suggested by equation (1) in studies of aggregate investment behavior. Rather than assume the geometric decay capacity depreciation pattern to be true, equation (8) allows one to utilize estimates of the set of h_i weights based on microdata set analysis. Equation (8) is preferred over equation (4) as equation (8) specifically allows for a separate accounting of factors causing change to the productive capacity of the capital stock over time and narrows this focus to a single measure of the capital stock.

Given the assumption that annual capital expenditures for farm tractors valued in 1967 prices are an acceptable measure of the productive capacity of farm tractors when originally acquired, capacity depreciation for tractors on farms in year t expressed in 1967 prices is given by

$$D_t = \sum_{k=0}^{\infty} h_k I_{t-k}, \tag{9}$$

where

$$N_t = K_{t+1} - K_t = I_t - D_t. \tag{10}$$

As $\sum_{i=0}^{k} h_i$ approaches one, the original productive capacity of farm tractors purchased in year $t - k$ is entirely lost due to physical deterioration.[6] Thus, equations (9) and (10) express current capital expenditures for farm tractors in terms of their real productive value rather than current market value. This reflects the assumption that firms consider the relative efficiency of different vintages of farm tractors when restoring or expanding the productive capacity of their existing capital stock.

Estimation of Physical Deterioration

If θ_m represents the additional fraction of the original productive capacity of tractors requiring repairs and maintenance during the mth year and ξ_m represents that fraction of current and past physical deterioration not repaired during the mth year, then current needed repairs and maintenance expressed as a fraction of the original purchase in the mth year (NR_m) is given by[7]

$$NR_m = \theta_m + \sum_{i=1}^{m-1} \left[\prod_{j=1}^{i} \xi_{m-j} \right] \theta_{m-i}. \tag{11}$$

The first component (θ_m) represents the effect of current physical deterioration, while the second component represents the sum of postponed repairs and maintenance in previous years. Given equation (11), observed repairs and maintenance expressed as a fraction of the original purchase price in the mth year after its original purchase must equal

$$OR_m = (1 - \xi_m)\theta_m + (1 - \xi_m) \sum_{i=1}^{m-1} \left[\prod_{j=1}^{i} \xi_{m-j} \right] \theta_{m-i}, \tag{12}$$

or needed repairs and maintenance times the fraction not postponed. Solving for θ_m and reducing terms,

$$\theta_m = (OR_m)/(1 - \xi_m) - \xi_{m-1}((OR_{m-1})/(1 - \xi_{m-1})). \tag{13}$$

The set of h_i, defined earlier as the fraction of the original productive capacity lost due to physical deterioration during the mth year, is therefore given by

$$\sum_{i=0}^{m} h_i = \sum_{i=0}^{m} (\theta_i - OR_i), \tag{14}$$

which represents the numerator in the capacity depreciation pattern suggested by equation (9). This also implies that

[6] We assume, as did Coen, that the value of h_0 is independent of the calendar date at which the capital good was originally purchased. The effect of this assumption is negligible in the present study due to the concave shape of the ED pattern over the service life of farm tractors. The effect of this assumption is much greater in those studies that, like Coen, assume a geometric decay capacity depreciation pattern that is convex rather than concave to the origin.

[7] The original purchase price and observed annual repair and maintenance costs are expressed in constant rather than current dollars.

$$(15)\quad 1 - \sum_{i=0}^{m} h_i = 1 - ((\xi_m)/(1 - \xi_m))OR_m,$$

which represents the key piece of information needed to measure K_t in equation (8) when $h_0 = 0$. The capacity depreciation pattern for farm tractors suggested by equation (15) is a function of one observed variable (OR_m) and a behavioral assumption as to the manner in which needed repairs and maintenance are postponed by farm operators over the service life of the tractor (ξ_m).[8]

A recent survey by Hunt provides information on annual repairs and maintenance costs, annual amounts of use and the original purchase price for 745 farm production machines spanning the 1958–74 period. Hughes recently estimated the following polynomial relationship for those farm tractors in Hunt's survey for which a continuous record was maintained:

$$(16)\quad \sum_{i=1}^{m} OR_i = \underset{(0.0005)}{0.0047\ m^2} - \underset{(0.00008)}{0.0002\ m^3}, \qquad \bar{R}^2 = 0.53,$$

where the figures in parentheses are the standard errors of the coefficients.[9] Equation (16) reaches its maximum approximately sixteen years after the original purchase of the farm tractor. By this time, cumulative observed repairs and maintenance are almost 40% of the original purchase price. In addition, the inflection point is approximately eight years after the original purchase of the tractor. This suggests that maximum annual repair and maintenance costs, which total approximately 4% of the original purchase price, are incurred in the eighth year.[10] Importantly, the results found by Hughes can be used in this study to determine the numerator in equation (15).

Before we can use equation (15), however, we must examine the distribution of ξ_m over the service life of the farm tractor. Since this information is not available from Hunt's survey, annual values for ξ_m are derived based on hypothesized management behavior. To begin with, two things are known about its distribution: ξ_m is equal to one when OR_m is equal to zero, which was shown above to occur sixteen years after the original purchase of the tractor, and both ξ_m and $\sum_{i=1}^{m} OR_i$ reach their maximum in the same year. A review of literature also suggests potential characteristics regarding machinery management behavior. According to Bowers, "putting off repairs only leads to more serious problems, including a high percent of downtime and even higher repair bills" (p. 35). Thus, ξ_m is expected to be relatively small in the early years of the service life of the tractor. As the tractor becomes older and needed repairs and maintenance increase due to physical deterioration, ξ_m is likely to increase at an increasing rate up to a point where minimum repair and maintenance needs are met. At the point where no further repairs are made, ξ_m equals one.[11] Based on this assumed

[8] This equation does not reflect the impact of downtime incurred during normal production hours on the productive capacity of existing farm tractors. Downtime can occur due to physical deterioration associated with either accumulated use or accidental damage. Letting the right-hand side of equation (15) be represented by Γ_m, the effects of downtime in year m can be measured by

$$1 - \sum_{i=1}^{m} h_i = \Gamma_m(1 - \alpha_m),$$

where α_m is that fraction of the original productive capacity lost during the mth year after its original purchase due to downtime. Unfortunately, Hunt's survey provides only a limited number of cases where adequate information on downtime was kept. In those cases, the average downtime reported during normal production hours expressed as a fraction of downtime plus hours used was only 2.7%. Further, no particular relationship between α_m and m was evidenced. Since α_m refers to downtime during normal production hours, the argument that "the older a tractor is, the more time is spent on repairs" does not necessarily imply a greater amount of downtime. In view of this, the lack of any relationship between α_m and m appears less suspect.

[9] While one would expect difficulties in applying equation (16) at the micro level, it should be unbiased when applied to all farm tractors if Hunt's sample is representative of the total population. The relatively low coefficient of determination found by Hughes for equation (16) might be the result of regressing $1 - \sum_{i=1}^{m} OR_i$ on age (m) rather than cumulative hours of use, and the hypothesis of geometrically declining use therefore has not been rejected. To dispel this possibility, the annual hours of use given by the hour meters placed on the farm tractors in Hunt's survey are regressed on age for the first seven full years of use. Based on the empirical results, we are unable to reject the hypothesis that the coefficient associated with the variable age is significantly different from zero at the 5% probability level, implying a constant level of use over this time period. In addition, $\sum_{i=1}^{m} OR_i$ is regressed on cumulative hours of use over the sample period used by Hughes to estimate equation (16). The coefficient of determination is almost identical to that reported for equation (16), which one would expect based on our failure to observe any relationship between annual hours of use and age. These results, when added to those reported by Hughes, suggest that the assumption that tractors are used more in the early years of their service life and are therefore consumed in a like manner is not true.

[10] Discussions with agricultural extension agents suggest that farm operators quit making repairs on tractors between the ages of twelve to twenty years. The results presented for equation (17) seem reasonable, since the maximum of sixteen years is within this range.

[11] While the machinery management behavior assumed in this study seems to be the most logical, others could be proposed. The effects of alternative repair and maintenance postponement assumptions on the convexity of the capacity depreciation pattern are examined. The only assumption that altered the convexity of

aggregate management behavior, the distribution of ξ_m over the service life of farm tractors takes the following polynomial form:

$$\xi_m = a_1 m^2 + a_2 m^3. \tag{17}$$

Given equation (17), one can set up a system of two simultaneous equations with two unknowns (a_1 and a_2). Solving this system of equations for a_1 and a_2 and substituting the solution values into equation (17),

$$\xi_m = 0.01172\, m^2 - 0.00049\, m^3. \tag{18}$$

Equations (16) and (18) together provide the necessary information to solve for the set of h_t weights in equation (15).

Comparison with Other Patterns

The final capacity depreciation pattern illustrated by figure 1 is that suggested by the solution of equation (15). This capacity depreciation pattern, denoted by *ED*, is concave rather than convex in shape with respect to the origin, falling in between the OHS and SL capacity depreciation patterns. Interestingly, the ED pattern is substantially different from the geometric decay patterns that, like those assumed by the USDA, are convex in shape with respect to the origin.

Table 1 presents a comparison of the real current market and real productive values for the capital stock and capital flows of farm tractors given by equations (1) through (3) and equations (8) through (10), respectively. Clearly, a substantial difference exists in the values for the capital stock as well as for the net investment and replacement capital flows. The USDA estimates imply a lower level of productive capacity for the stock of farm tractors during 1948–74 than that suggested by the ED capacity depreciation pattern. In addition, the majority of the depreciation of farm tractors purchased new during the post-World War II machinery purchase boom of 1948–53 should not have shown up in the accounts until the late 1950s and early 1960s if the ED capacity depreciation pattern given by equation (15) is reflective of actual losses. This suggests, therefore, that the USDA depreciation series likely underestimates the level of net investment and net farm income during most of the 1950s and overestimates these flows of funds during most of the 1960s. Thus, the researcher's selection of capacity depreciation pattern does have a substantial impact on the magnitude of the capital stocks and capital flows employed in empirical analyses.

Implications for Further Research

Initially, several revisions to the present economic accounts for the farm production sector should be considered in light of the results presented in this study. At a minimum, the real productive value of the capital stock and capital flows for farm tractors suggested by this study should be considered for publication along with their current market value in *Balance Sheet for the Farming Sector* and in *Farm Income Statistics*, respectively. Similar microdata set analyses should also be undertaken to measure the real productive value for other types of farm production machinery and farm buildings. When summed together, analysts and policy makers will be in a better position to assess the level of current expansion of farm business capacity implied by the current dollar estimates of net investment in plant and equipment published in *Farm Income Statistics* and net capital formation proposed by Simunek. When expressed in constant dollars, the capital flow account proposed by Simunek will understate annual real net capital formation and overstate real capital gains to the extent that the present depreciation series in constant dollars overstates capacity depreciation.

The present depreciation series also poses a paradox to the followers of the net farm income estimate published in *Farm Income Statistics*. Its description suggests an accounting of capacity depreciation or that expenditure required to keep capital intact, while the depreciation pattern used to approximate this data series better conforms to that suggested by economic depreciation. To the extent that the current dollar estimate of depreciation overstates the replacement cost for plant and equipment used up during the year, the net farm income data series will be understated. Finally, a study should be undertaken to identify those factors that explain why the current market price for used tractors in secondary machinery markets differs from the average

the ED pattern is one of total postponement of repairs and maintenance in the early stages, constantly decreasing postponement thereafter until all needed repairs and maintenance are made at the end of the service life of the tractor. It seems illogical, if not impossible, to assume that farm operators in general allow their tractors to deteriorate when at their greatest productive level and then make all repairs and maintenance as they approach the end of their service life.

Table 1. Real Productive Value of the Current Capital Stock and Capital Investment Flows for Farm Tractors Suggested by Alternative Depreciation Patterns, 1948–74

Year	Capital Stock[a]		Depreciation		Net Investment	
	GD-USDA Pattern	ED Pattern	GD-USDA Pattern	ED Pattern	GD-USDA Pattern	ED Pattern
	Billion $					
1948	4.12	9.12	0.47	0.21	0.73	1.00
1949	4.82	10.04	0.56	0.34	0.70	0.92
1950	5.45	10.82	0.62	0.47	0.63	0.78
1951	5.97	11.50	0.72	0.55	0.52	0.68
1952	6.33	12.02	0.77	0.61	0.36	0.53
1953	6.60	12.64	0.81	0.46	0.27	0.61
1954	6.64	12.94	0.83	0.57	0.04	0.31
1955	6.83	13.25	0.85	0.73	0.19	0.31
1956	6.73	13.14	0.85	0.86	−0.10	−0.11
1957	6.59	13.10	0.84	0.75	−0.14	−0.04
1958	6.64	13.39	0.83	0.59	0.05	0.29
1959	6.79	13.44	0.84	0.94	0.15	0.05
1960	6.56	13.29	0.84	0.76	−0.23	−0.15
1961	6.46	13.21	0.82	0.79	−0.10	−0.08
1962	6.46	12.94	0.81	1.10	0	−0.28
1963	6.57	12.60	0.80	1.24	0.11	−0.33
1964	6.70	12.34	0.83	1.22	0.13	−0.26
1965	6.92	12.24	0.85	1.18	0.22	−0.11
1966	7.28	12.36	0.89	1.13	0.36	0.12
1967	7.52	12.49	0.93	1.04	0.24	0.13
1968	7.70	12.64	0.96	0.98	0.18	0.16
1969	7.76	12.82	0.97	0.85	0.06	0.18
1970	7.87	12.97	0.98	0.94	0.11	0.14
1971	7.96	13.32	0.99	0.73	0.09	0.36
1972	7.23	13.84	1.02	0.77	0.27	0.51
1973	8.73	14.50	1.07	0.90	0.50	0.67
1974	8.95	14.96	1.13	0.90	0.22	0.46

[a] GD-USDA is based upon the geometric decay pattern assumed by the USDA. ED denotes the engineering data pattern given by equation (15). Capital stock at the end of the year.

productive value of tractors of like vintage retained on farms.

There are also important implications for further research associated with estimation of aggregate production functions or investment behavior models. Several previous studies have used the USDA depreciation data series when estimating the parameters in aggregate farm production functions based on factor or relative market shares. Tyner and Tweeten, for example, used the sum of depreciation in current dollars and the opportunity interest charge as a measure of machinery capital services in estimating factor shares for production inputs. Rosine and Helmberger added depreciation to net imputed returns, both expressed in 1957 prices, in estimating the relative market shares for capital inputs. If farm production machinery does wear out at a slower rate in the early years of their service life than in the latter stages as shown for farm tractors, and if the annual rate of embodied technical progress is positive, present measures of annual capital services will lead to inconsistent estimates of production elasticities. In addition, the compound geometric lag hypothesis described by Kmenta would suggest that net investment in farm tractors is a function, in part, of the productive capacity of existing capital and the lagged dependent variable. Thus, the time-series values for the dependent variable and at least two independent variables in a net investment regression model for farm tractors would be directly affected by the capacity depreciation pattern assumed by the researcher. Cromarty, in one of three previous econometric studies focusing on the demand for farm tractors, implicitly assumed the OHS pattern, while Heady and Tweeten assumed a geometric decay pattern. Finally, Griliches examined the effects of both the OHS and geometric decay patterns, concluding that "the truth may lie somewhere in between these two extremes" (p. 202). We suggest that the parameter estimates presented in these studies are also inconsistent due to the

measurement error associated with their dependent and selected independent variables. Further research is needed to determine the relative effect of the ED pattern on these parameter estimates.

Summary

The approach taken to measure the capacity depreciation of farm tractors was one based on utilizing available engineering data. Rather than assuming that the productive capacity of farm tractors declines geometrically, not at all until the last year of its service life, or something in between, information from a recent agricultural engineering survey was used in an attempt to measure actual capacity depreciation. This pattern yields estimates of the real productive value of the existing stock of farm tractors and selected capital flows that differ substantially from those approximated by the USDA. While any specific implications drawn from these results are necessarily limited to those stocks and flows pertaining to farm tractors, there are obvious spill-over effects for other types of farm production machinery and farm buildings. It makes little sense to assume, for example, that farm buildings deteriorate in a geometric fashion. Yet, the estimate of annual depreciation of farm service buildings and farm household dwellings published in *Farm Income Statistics* is also approximated by a constant percentage of the existing capital stock.

As Klein suggests, "Econometricians would be well advised not to lock themselves into committed positions and let data and engineering considerations do some work for them in finding good specifications" (p. 45). The payoffs from working more closely with agricultural engineers in the further development of the economic accounts and model design are likely to be substantial.

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Determinants of Milk Advertising Effectiveness

Stanley R. Thompson and Doyle A. Eiler

An analysis of the net returns to dairy farmers from generic fluid milk advertising is made in terms of the ability of advertising to increase the blend price of milk in excess of the cost of advertising. The evaluation of the economic effectiveness of generic fluid milk advertising programs extends beyond the measurement of the direct sales response to advertising. Specifically, the class I-class II price differential and the class I utilization rate are found to be extremely important factors influencing the effectiveness of generic milk advertising programs, while the impact of the price elasticity of supply is relatively minor.

Key words: advertising, fluid milk, generic promotion, milk marketing, polynomial distributed lag.

Most empirical investigations of the economic impact of fluid milk promotion programs have been confined to estimating the responsiveness of sales to given levels of promotion (Clement, Henderson, and Eley; Thompson and Eiler). However, evaluation of the economic effectiveness of a fluid milk advertising program extends beyond the measurement of the direct sales response to advertising.

The major question confronting dairy farmers is whether or not advertising can increase the blend price sufficiently to cover the cost of the advertising effort. This increase in the blend price due to advertising provides a measure of the economic effectiveness of generic fluid milk advertising. Accordingly, the impact of a given advertising expenditure is largely determined by such factors as the class I-class II price differential, the class I utilization rate, the price elasticity of supply, the direct responsiveness of milk sales to advertising and, of course, the level of advertising expenditure. Thus, the purpose of this study is to investigate the economic impact of supply response, class price differentials, and utilization rates on generic fluid milk advertising effectiveness. In this quest, a generalized theoretical framework characterizing milk blend price determination is developed with emphasis placed on the role of generic advertising in changing the blend price.

Economic Model

The industry farm level supply and demand relations are defined, respectively, as

$$Q = S(P), \tag{1}$$

which is equal to the horizontal summation of the marginal cost functions of each firm in the industry, exclusive of the cost of advertising,[1] and

$$Q = D(P,A), \tag{2}$$

where Q is total quantity of milk, P is farm-level price (blend price) for milk, and A is total dollar investment in generic advertising. If the supply and demand relationships are restricted to certain functional forms, the system can be explicitly solved for the equilibrium price (P^*) and, by substitution, for the equilibrium quantity (Q^*).[2]

Stanley R. Thompson is an assistant professor of agricultural economics at Michigan State University, and Doyle A. Eiler is an assistant professor of marketing at Cornell University.

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[1] One way to account for advertising investment cost in the analysis is to specify advertising explicitly in the supply function. In this manner, the supply schedule will shift upward by the amount of the advertising investment. However, this procedure complicates the determination of equilibrium values. Alternatively, a more convenient approach is to deduct the cost of advertising directly from the net change in the equilibrium blend price due to advertising. The latter procedure is adopted for this analysis.

[2] Within a static equilibrium framework, Nerlove and Waugh

In most milk markets, a classified pricing system is used to determine the farm-level price of milk. The price farmers receive is a weighted average (i.e., blend price) of exogenously determined prices for fluid milk (class I) and manufacturing milk (class II). This farm level blend price relationship is expressed as follows:

$$(3) \qquad P = \left[\frac{Q_I}{Q}\right] P_I + \left[\frac{Q - Q_I}{Q}\right] P_{II}$$

for $0 < Q_I < Q$, where Q_I is quantity of milk utilized in class I, $Q - Q_I$ is quantity of milk utilized in class II, P_I is price of class I milk, and P_{II} is price of class II milk.[3] Solving equation (3) for Q yields

$$(4) \quad Q = Q_I\,[(P_I - P_{II})/(P - P_{II})] \qquad \text{for } P_{II} < P < P_I.$$

While advertising is not an explicit argument of equation (4), it is implicit in Q_I (see footnote 5 for explicit relationship between Q_I and advertising). Thus, equation (4) can be used in solving for market equilibrium.

If the supply schedule is expressed as a linear function of price,

$$(5) \qquad Q = \gamma + \delta P,$$

then market equilibrium occurs when the quantity supplied in equation (5) equals the quantity utilized in equation (4), or

$$(6) \quad Q_I\,[(P_I - P_{II})/(P - P_{II})] = \gamma + \delta P.$$

Solving equation (6) for the equilibrium blend price (P^*) yields

$$(7) \quad P^* = [-(\gamma - \delta P_{II}) \pm \{(\gamma - \delta P_{II})^2 + 4\delta\,[\gamma P_{II} + Q_I(P_I - P_{II})]\}^{1/2}]/2\delta.$$

The equilibrium blend price (P^*) must lie in the range $P_{II} \leq P^* \leq P_I$. Thus, only the positive root of the quadratic in equation (7) need be considered.

It is evident from this derivation that the equilibrium blend price P^* is influenced by (*a*) the price elasticity of supply, (*b*) the class I-class II price differential, (*c*) the ability of advertising to increase class I sales, and (*d*) the proportion of the total milk production sold as class I.

Figure 1 depicts the comparative static equilibrium effects of fluid milk advertising as defined by equations (4) and (5). Let the initial equilibrium blend price and quantity be P^*_0 and Q^*_0, respectively, and the class I and class II prices (P_I and P_{II}) set the respective upper and lower boundaries of the price-quantity schedule. The prices P_I and P_{II} are exogenously determined under most classified milk-pricing programs (i.e., they are based on a relationship to the Minnesota-Wisconsin price for manufactured products). Further, Q_I^0 is defined as the quantity of class I fluid milk sold to processors at price P_I, and the difference between the total market sales Q^*_0 and Q_I^0 is the quantity sold as class II. Suppose that fluid milk advertising increases the quantity of class I sales from Q_I^0 to Q'_I and that the effect of this increase in class I sales is to shift the price-quantity relationship from $D_0D'_0$ to $D_1D'_1$. Allowing for supply response, the effect of the increased class I sales is not to increase the blend price to P'_0 at quantity Q^*_0 but rather, after complete adjustment, to establish a new *ex post* equilibrium at a somewhat lower price P^*_1 with a somewhat greater total quantity Q^*_1.

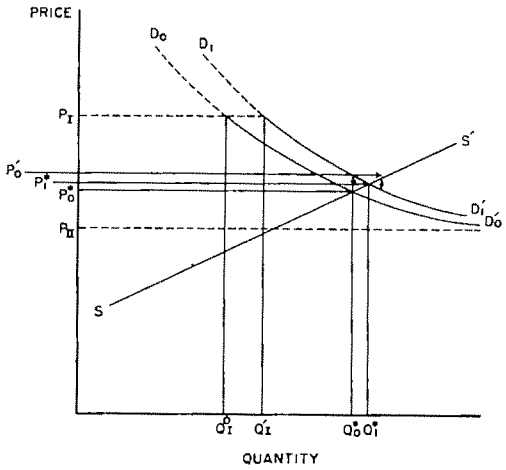


Figure 1. Blend price—quantity relationships and equilibrium prices resulting from a shift in demand

Empirical Results

The Data and the Model

Data were obtained on fluid milk sales and prices, personal income, population, competitive beverage prices, generic milk advertising expenditures, and other competitive beverage

have conceptualized the unique nature of advertising without supply control. For the most part, Nerlove and Waugh's theoretical conceptualization fits the conditions surrounding the fluid milk advertising problem and, therefore, a special case of their framework is adopted here.

[3] When $Q_I = 0$, $P = P_{II}$, and when $Q_I = Q$, $P = P_I$.

advertising in the New York City standard metropolitan statistical area (SMSA). Monthly observations were available from January 1971 to March 1974 (Thompson, Eiler, and Forker). Considerable monthly variations in both sales and advertising expenditures prevailed over the thirty-nine-month period.

Class I milk sales include sales of regular whole milk, low fat milk, skim milk, and milk drinks. These sales data represent actual net fluid milk sales after adjusting for shipments entering and exiting the SMSA. Moreover, since sales differ dramatically depending on the day of the week, each monthly sales statistic was adjusted for the number of each day of the week in the month and placed on a daily basis. These monthly adjusted sales data were placed on a per capita basis using the population within the SMSA.

The generic fluid milk advertising data are defined according to the media coverage area (MCA), where the population of the New York City MCA is about 50% larger than its respective SMSA population. The monthly advertising expenditures were placed on a per capita basis according to the MCA population and then deflated by an index of the cost of prime-time spot television. More than 85% of the media expenditures were for television, and no basic changes occurred in the advertising theme during the sample period.

Since class I sales are substantially less than total milk sales and fluid milk advertising is presumed to directly influence only class I sales, a single equation econometric model can be estimated. In addition, since much of the empirical advertising literature suggests the existence of diminishing marginal returns to advertising (see Simon), an econometric sales response model capable of exhibiting this characteristic was specified. Using a polynomial distributed lag model to obtain an estimate of the long-run influence of advertising on sales, the following ordinary least-squares estimates were obtained:[4]

$$
\begin{aligned}
(8)\quad \ln q_I = {} & 0.8839 + \underset{(1.02)}{0.0082}DJAN \\
& + \underset{(4.11)}{0.0314}DFEB + \underset{(3.45)}{0.0267}DMAR \\
& + \underset{(1.65)}{0.0139}DAPR + \underset{(0.44)}{0.0036}DMAY \\
& - \underset{(1.67)}{0.0136}DJUN - \underset{(14.36)}{0.1037}DJUL \\
& - \underset{(12.04)}{0.0908}DAUG - \underset{(2.74)}{0.0202}DSEP \\
& + \underset{(0.36)}{0.0026}DOCT - \underset{(1.37)}{0.0096}DNOV \\
& + \underset{(0.44)}{0.1528}\ln INC - \underset{(7.45)}{0.2032}\ln PRC \\
& + \underset{(2.06)}{0.0040}\ln a_t + \underset{(2.70)}{0.0026}\ln a_{t-1} \\
& + \underset{(3.00)}{0.0029}\ln a_{t-2} + \underset{(5.09)}{0.0038}\ln a_{t-3} \\
& + \underset{(5.20)}{0.0044}\ln a_{t-4} + \underset{(3.99)}{0.0035}\ln a_{t-5}; \\
& \bar{R}^2 = 0.966; \qquad DW = 1.98;
\end{aligned}
$$

where q_I is per capita daily class I milk sales in ounces, adjusted for the type of days in the month, i.e., number of Sundays, Mondays, etc.; *DJAN . . . DNOV* are eleven zero-one dummy variables with December as the base class; *INC* is deflated per capita annual personal income in dollars; *PRC* is deflated (by consumer price index, 1967 = 100) retail price in dollars of whole fluid milk in paper half gallons; and the a_{t-i} are deflated actual per capita monthly media advertising expenditures (in dollars) lagged i periods, where $a = A/\text{SMSA}$ population. The figures in parentheses are computed t-ratios of the estimates. The combined direct and carryover elasticity of advertising is 0.0212 (a t-ratio of 4.84).

Since the theoretical model previously presented focused on market equilibrium and the relationship between class I sales and fluid milk advertising (equation (8)) was estimated on a per capita basis to obtain an empirical estimate of the market level blend price-quantity relationship, an aggregation procedure is necessary. Using the mean value for all of the variables except advertising, the per capita demand function, equation (8), can be aggregated to yield the following class I market demand function:[5]

[4] Using the Lagrangian interpolation procedure, a polynomial distributed lag model was used to estimate the long-run influence of advertising. The criteria and procedures used to select the degree of polynomial and length of the lag can be found in Thompson, Eiler, and Forker. Based on these criteria, a third-degree polynomial of lag length five was selected to best represent the lagged response of sales to advertising in New York City.

[5] The market demand function (equation (9)) is derived by using the estimated per capita class I demand function (equation (8)) and the assumptions: (*a*) the average SMSA population in New York City is 11,702,221, (*b*) 14.88372 fluid ounces per pound of 3.5% test milk, (*c*) 365 days per year, (*d*) 100 pounds per hundredweight, and (*e*) 2.290765 is the sum of the nonadvertising coefficients

(9) $$Q_I = 2{,}869{,}787e^{2.2908}a^{0.0212}.$$

Employing the analytical framework and the estimated sales response model, the equilibrium blend price associated with a particular advertising level can be calculated. The difference between the equilibrium blend price with a particular advertising level and the equilibrium blend price with no advertising is the imputed return dairy farmers receive from the advertising program, i.e., the increase in the blend price due to advertising.[6] However, as indicated by the economic model, the class price differential, the utilization rate, and the nature of supply response all have a direct bearing on the returns dairy farmers receive. In the subsequent discussion the role of each of these factors in determining the blend price increase associated with advertising is examined further.

Price Differentials and Utilization Rates

The Federal Milk Marketing Order No. 2 for the New York-New Jersey milk marketing area specifies that the price for class I milk is the Minnesota-Wisconsin price in the second preceding month plus \$2.40 per hundredweight (USDA 1971), whereas the class II price is the current month's Minnesota-Wisconsin price plus seasonal adjustment. Thus, the actual class I-class II price differential may be greater or less than \$2.40 per hundredweight, depending upon the month-to-month Minnesota-Wisconsin price variation and the seasonal adjustment (USDA 1971). Since substantial variation in the class price differential can occur, the size of this differential is potentially an important determinant of the effectiveness of generic advertising.[7]

Using a price elasticity of supply of 0.8 (Jackson, p. 67), the sensitivity of the blend price increase due to a deflated monthly advertising expenditure of \$0.00575 at selected class price differentials and utilization rates is shown in table 1.[8] As shown, the change in the blend price due to advertising is quite sensitive to both changes in the class I-class II price differential and the utilization rate. The estimated sales response to advertising (from equation (9)) is identical for each cell in table 1; only the economic effectiveness differs.

While different milk marketing areas generally experience different class I utilization rates, within a particular milk market these

evaluated at the mean value of their variables. Therefore, $Q_I = \frac{(11{,}702{,}221)(365)}{14.88372(100)} e^{2.290785}a^{0.02115737} = 2{,}869{,}787e^{2.290785}a^{0.02115737}$.

[6] Since the double-log sales response function is incapable of handling zero advertising expenditures, a "very small" monthly per capita advertising level of \$0.0001 was used.

[7] For example, during 1975 the corresponding range in the monthly class I-class II price differentials for the following federal order markets were: New York City, \$1.58–\$2.60 per hundredweight; Chicago, \$0.24–\$1.15 per hundredweight; New Orleans, \$1.83–\$2.74 per hundredweight; and Oklahoma Metro, \$0.96–\$1.87 per hundredweight (USDA 1975–76).

[8] This represents the "optimum" level of advertising for New York City in the sense that with a supply elasticity of 0.80 net producer returns to advertising are maximized (Thompson, Eiler, and Forker, p. 13). The blend price increases reported in table 1 depend upon the level of advertising. Increasing the level of advertising would increase the blend price, but it would also cause the ridge line in table 1 to migrate toward the southwest due to the diminishing returns of advertising. Regardless of the level of advertising, the relationship between adjacent table elements remains the same.

Table 1. Increase in the Equilibrium Blend Price Due to Advertising, New York City SMSA

Utilization Rate in Class I	Class I-Class II Price Differentials							
	3.20	2.80	2.40	2.00	1.80	1.60	1.40	1.20
	\$/cwt.							
0.40	0.096	0.084	0.074	0.062	0.056	0.050	0.044[a]	0.039[a]
0.45	0.106	0.094	0.082	0.069	0.062	0.056	0.049	0.043[a]
0.50	0.117	0.104	0.091	0.076	0.069	0.062	0.055	0.048
0.55	0.127	0.113	0.098	0.083	0.075	0.067	0.060	0.052
0.60	0.137	0.122	0.106	0.091	0.082	0.074	0.065	0.056
0.65	0.148	0.131	0.114	0.097	0.088	0.079	0.070	0.061
0.70	0.158	0.140	0.122	0.104	0.094	0.084	0.075	0.065
0.75	0.167	0.149	0.130	0.110	0.100	0.091	0.080	0.069
0.80	0.177	0.158	0.137	0.117	0.106	0.096	0.084	0.074
0.85	0.186	0.166	0.145	0.123	0.113	0.101	0.089	0.078
0.90	0.197	0.175	0.153	0.130	0.118	0.106	0.094	0.082
0.95	0.206	0.184	0.160	0.136	0.124	0.111	0.099	0.086

Note: The figures in this table are based on deflated per capita monthly direct media advertising expenditure of \$0.00575 and price elasticity of supply of 0.80.

[a] The increase in blend price is less than the cost of the advertising program.

utilization rates are quite stable over time and indeed substantially less volatile than the class I-class II price differential. Thus, an awareness of the magnitude of this price differential and its expected change over time has some important advertising program planning and policy implications.

As evident from table 1, the higher the class I utilization rate, the greater the impact of advertising on the blend price. Also, since a successful milk advertising program has the effect of shifting milk from class II to class I utilization, the greater the class I-class II price differential, the greater the increase in the blend price (where $P_I > P_{II}$). Assuming a 50% utilization rate, the increase in the blend price due to advertising is 16% less for a class I-class II price differential of $2.00 per hundredweight than for a price differential of $2.40 per hundredweight.

A major implication from the relationships shown in table 1 is that the benefits from advertising are greatest in milk markets with high class I-class II price differentials and high class I utilization rates. These specific findings are, of course, conditional on the highly significant sales response to advertising relationship observed in New York City. Nonetheless, the general relationships between adjacent elements in table 1 hold regardless of the magnitude and/or significance of the estimated advertising parameter.

Clearly, the degree of responsiveness of sales to advertising is not the only factor affecting the economic effectiveness of fluid milk utilization rates, and class price differentials are highly important determinants. In particular, the response of sales to advertising in other markets may be substantially less than the estimated response in New York City, but the advertising effort can still be profitable if the class price differentials and the utilization rates are high.

Supply Response and Advertising

The change in the blend price from advertising at various price elasticities of supply is shown in figure 2. An inverse relationship between the price elasticity of supply and the blend price increase is observed. The sensitivity of changes in the blend price to alternative elasticities of supply, however, is relatively low—especially over realistically small changes in elasticities. For example, increases in the supply elasticity from the short-run level of

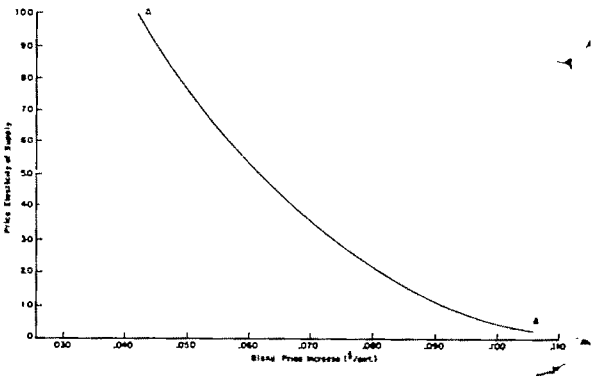


Figure 2. Blend price increase due to advertising for alternative supply elasticities, New York City SMSA. Based on: (*a*) deflated per capita monthly direct media advertising expenditure of $0.00575, (*b*) class I-class II price differential of $2.40 per hundredweight, and (*c*) class I utilization of 53%.

0.25 in the northeast United States to the long-run level of 0.80 (Jackson) decrease the change in the blend price from $0.1025 to $0.095, or by only about 7%.

There are an infinite number of figures like figure 2 for various combinations of class price differentials and utilization rates. Also, figure 2 and table 1 are related; that is, where the class I-class II price differential equals $2.40 per hundredweight, the utilization rate equals 53%, and the supply elasticity equals 0.80, the change in the blend price common to both figure 2 and table 1 is approximately $0.096 per hundredweight.[9]

Net Producer Returns

Since the estimated effect of advertising on sales in equation (8) is positive, the change in the equilibrium blend price (equation (7)) is also positive. However, the important question confronting dairymen and those managing the advertising program is whether or not the increase in the blend price is greater than the cost of the advertising effort.

The deflated per capita monthly direct media advertising expenditure of $0.00575 implies a cost of $0.045 per hundredweight to finance the program.[10] Thus, the areas where

[9] During the sample period of this study, the observed class I milk utilization rate in Federal Order No. 2 averaged 53%.

[10] Direct media cost = $0.00575 × 12 × (mean New York City SMSA population) × (current cost of media index) = $0.00575 × 12 × 11,702,221 × 1.80 = $1,453,416. Total cost of the advertising program includes the direct media cost plus the cost of program development and administration. In New York, these costs are

the increase in the blend price exceeds the cost of the advertising program are located southwest of the ridge line drawn in table 1. Notwithstanding the precise position of this ridge line, the higher the class I utilization and the greater the class I-class II price differential, the greater the returns to advertising.[11]

In Federal Order No. 2, where the class I utilization rate has averaged 50% to 55% and the class I-class II price differential about $2.40 per hundredweight, the net increase in the blend price over program costs ranges from $0.046 to $0.053 per hundredweight for utilization rates of 50% and 55%, respectively. The reader should bear in mind that these specific returns are conditional on the responsiveness of sales to advertising in the New York City market, the selected level of advertising expenditure, and the assumed price elasticity of supply.[12]

Summary and Implications

The general findings are that both the class I-class II price differential and the class I utilization rate are extremely important factors influencing the effectiveness of generic milk advertising programs. On the other hand, the impact of the price elasticity of supply on the economic effectiveness of advertising was relatively minor. Although our empirical investigation was for a particular market, the basic relationships hold regardless of the responsiveness of fluid milk sales to advertising and are extendable to markets for which advertising response estimates are not available.

A major implication of this study is that generic fluid milk advertising is likely to be more effective in markets maintaining "large" class I-class II price differentials, "high" class I utilization rates, and "low" price elasticities of supply. Since these factors are generally determined by the structural characteristics of milk markets, their interrelationships have important regional implications for improved generic advertising decision making. Further, the class I-class II price differential in many milk markets varies substantially over time. Thus, improved temporal expenditure decisions can be made. The advertising program planning implications of this temporal variability can be particularly important, since the level of the class I-class II price differential can often be anticipated several months in advance.

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approximately 46% of direct media cost. Thus, the total cost of the advertising program would be $2,121,987. On a hundredweight basis the cost is $0.045 per hundredweight. The above calculations assume a perfect congruence between the media coverage area, SMSA, and the milk shed. As divergences occur (as they always do in the real world), leakages appear that increase the cost of executing the program relative to the benefits that accrue to the program's supporters. New York dairy farmers have this problem in the New York media coverage area, where 20% of the milk sold does not contribute to the advertising program.

[11] The greater the responsiveness of sales to advertising, the more successful advertising will be in increasing the blend price. However, in markets where sales are less responsive than those estimated for the New York City market, the ridge line will move toward the southwest corner of table 1, notwithstanding identical levels of advertising.

[12] These results assume a price elasticity of supply of 0.80 and the estimated sales response function in equation (8).

On Two Strategies for Choosing Principal Components in Regression Analysis

Ron C. Mittelhammer and John L. Baritelle

Two traditional methods used to form principal components (PC) regression estimates are reviewed, and small sample properties of the estimates are compared with OLS estimates. A Monte Carlo experiment is used to facilitate comparisons. Theoretical considerations and empirical observation indicate that the PC techniques tend to produce estimates lower in mean square error (MSE) than OLS estimates under conditions of high multicollinearity, low R^2, and small sample size. Although under these conditions the PC techniques may be preferred to OLS in the relative MSE sense, MSE in the absolute sense may still render the PC estimates useless in applications.

Key words: mean squared error, multicollinearity, principal components, regression.

The use of principal components (PC) in regression analysis has infrequently appeared in the literature since Hotelling first proposed the technique in 1933. Recently, an illuminating article by McCallum demonstrated the potential usefulness of PC in regression analysis (PC-OLS) when multicollinearity is present. Cheng and Iglarsh also discuss the use of PC-OLS in cases of strong multicollinearity. Conspicuously missing from the literature is a comparison of the two traditional methods of determining the components used to form PC-OLS estimates.

One method deletes those components having small characteristic roots. Deletion based on small characteristic roots implies little loss in the total variation of the independent variables. Kendall discusses this method, while it is applied by others such as Pidot and Barrett, Gerardi, and Hart. Kendall mentions deletion of components based upon t-ratios, and Massy uses such a criterion.

This paper briefly reviews the process of principal component deletion in regression analysis and develops a theory of component deletion via the characteristic root (CRC) and t-value (TVC) criteria (for a thorough treatment of principal components, see Anderson). The meaning and some of the statistical properties of the derived coefficients under each criterion are examined. To facilitate comparisons, a simulation model using each criterion is employed.

Ron C. Mittelhammer is a research economist, stationed at Washington State University, and John L. Baritelle is a research economist with the Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture.

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Principal Component Regression Model

Assume the classical linear model

$$Y = X\beta + U, \tag{1}$$

where β is a $k \times 1$ vector of unknown population parameters to be estimated associated with the fixed set of independent variables contained in the $(n \times k)$ X matrix, and the $(n \times 1)$ U vector contains random disturbances distributed $N(0, \sigma^2 I_n)$. Both X and Y are expressed in deviations from the mean, and the X's are divided by their respective standard deviations.

Let W be the $k \times k$ matrix consisting of $k \times 1$ orthonormal characteristic vectors (w_i) of the correlation matrix $T^{-1}(X'X)$, where $T = n - 1$. The $n \times k$ matrix of principal components (Z) stands in the following relation to X:

$$Z = XW \text{ and } ZW' = X, \tag{2}$$

since by orthogonality $W^{-1} = W'$.

Substituting equation (2) into equation (1)

for X, the relationship between Y and the principal components is defined as

$$Y = ZW'\beta + U = Z\beta^c + U, \tag{3}$$

where $\beta^c = W'\beta$ is the $k \times 1$ vector of population parameters corresponding to the principal components Z. The OLS estimate of β^c can be written as

$$\begin{aligned} b^c &= (Z'Z)^{-1}Z'Y \\ &= (W'X'XW)^{-1}W'X'Y \\ &= W'(X'X)^{-1}WW'X'Y \\ &= W'(X'X)^{-1}X'Y = W'b. \end{aligned} \tag{4}$$

Hence, the OLS estimates of the original parameters in equation (1) can be formed as

$$b = Wb^c. \tag{5}$$

A principal component OLS (PC-OLS) estimate of the β vector in equation (1) is an estimate that is formed by deleting the effects of certain components in estimating b by equation (5). This can be represented by replacing certain column vectors of W with zero vectors, resulting in a new matrix W^*. The PC-OLS estimate for a given sample can be represented as[1]

$$b^* = W^*b^c. \tag{6}$$

The PC-OLS estimate of equation (1) is therefore defined as

$$Y = Xb^* + e^*. \tag{7}$$

Different estimators within the PC-OLS class can be defined depending on the criterion used to delete components.

Characteristic Root Criterion

This criterion eliminates components having small characteristic roots. The motivation for utilizing such a criterion may be given in two parts.

First, components having small characteristic roots account for only a small part of the variation in the X variables. This can be seen by first noting that the total system variation (TSV) in the X variables can be represented as

$$\begin{aligned} \mathrm{TSV}(X) &= \mathrm{tr}(X'X) = \mathrm{tr}(X'XWW') \\ &= \mathrm{tr}(W'X'XW) = T\,\mathrm{tr}\,\Lambda \\ &= T\sum_{i=1}^{k}\lambda_i, \end{aligned} \tag{8}$$

since the matrix of characteristic vectors W can be used to diagonalize $T^{-1}X'X$. The TSV in the components Z is equal to TSV(X), since $W'X'XW = Z'Z$. Therefore, the proportion of the total system variation in the data set that is accounted for by the ith component is given by

$$\mathrm{V}(Z_i)/\mathrm{TSV}(Z) = T\lambda_i/T\sum_j\lambda_j = \lambda_i/\sum_j\lambda_j. \tag{9}$$

The smaller is the characteristic root λ_i, the smaller is the proportion of the total system variation accounted for by component Z_i.

Second, discarding components with small characteristic roots may result in large reductions in the variances of the estimates b^*_i. Since b^* is a linear combination of variables distributed $N(\beta^c, \Sigma_{b^c})$, b^* is distributed $N(W^*\beta^c, W^*\Sigma_{b^c}W^{*\prime})$. If

$$\Sigma_{b^c} = \sigma^2(Z'Z)^{-1} = \sigma^2(T\Lambda)^{-1}, \tag{10}$$

then

$$\Sigma_{b^*} = W^*\Sigma_{b^c}W^{*\prime} = \sigma^2T^{-1}W^*\Lambda^{-1}W^{*\prime}. \tag{11}$$

When no components are deleted, the ith diagonal entry of equation (11) represents an orthogonal decomposition of the variance of b_i as

$$\mathrm{var}\ b_i = \sigma^2T^{-1}\sum_{j=1}^{k}\frac{w_{ij}^2}{\lambda_j}. \tag{12}$$

Assuming that the last $k - k^*$ components are deleted, the gain in precision when using b^*_i in place of b_i can be written as

$$\mathrm{var}\ b_i - \mathrm{var}\ b^*_i = \sigma^2T^{-1}\sum_{j=k^*+1}^{k}\frac{w_{ij}^2}{\lambda_j}. \tag{13}$$

Deleting components with small characteristic roots is equivalent to deleting the variance terms having the smallest denominators in the decomposition of equation (12). This can lead to a great reduction in the variance of the estimator of β_i if the w_{ij}'s are relatively large and the λ_j's are relatively small. However, the magnitudes of the w_{ij}'s are determined by a complex relationship among the entries of the correlation matrix $T^{-1}(X'X)$, and little can be inferred about a given w_{ij} on the basis of the magnitude of a characteristic root.

Given the orthonormality of the set of vectors $\{w_1, w_2, \ldots, w_k\}$, the w_{ij}'s are bounded by $0 \le w_{ij}^2 \le 1$ and $\sum_j w_{ij}^2 = \sum_i w_{ij}^2 = 1$. Therefore, the variances of the estimates of one or more

[1] Variables in the original X-frame of reference are not deleted, and an estimate of the full β vector is always available.

entries in β are reduced relative to OLS estimation. Unfortunately, when using CRC there is no control on the bias introduced, where

$$(14)\quad \text{bias } b^*_i = Eb^*_i - \beta_i = \sum_{j=1}^{k^*} w_{ij}\beta_j^c - \sum_{j=1}^{k} w_{ij}\beta_j^c = -\sum_{j=k^*+1}^{k} w_{ij}\beta_j^c.$$

The principal components are functions of the correlation matrix $T^{-1}(X'X)$ without regard to the dependent variable Y, while the estimates of β_j^c are functions of the dependent variable in addition. Thus, the CRC results in deletion decisions made without information regarding the correlation between the dependent variable and the components. Referring to the mean square errors of the estimates, this deletion criterion can cause difficulties of varying degree, depending on the problem. The mean square error of b^*_i is defined as

$$(15)\quad \text{MSE } b^*_i = \text{var } b^*_i + (\text{bias } b^*_i)^2 = \sigma^2 T^{-1}\sum_{j=1}^{k^*}\frac{w_{ij}^2}{\lambda_j} + \left(-\sum_{j=k^*+1}^{k} w_{ij}\beta_j^c\right)^2.$$

The mean square error of the OLS estimate b_i is simply its variance in equation (12), since b_i is an unbiased estimate. Therefore, the mean square error of the PC-OLS estimate relative to the OLS estimate can be written as

$$(16)\quad \frac{\text{MSE } b^*_i}{\text{MSE } b_i} = \frac{\sum_{j=1}^{k^*} w_{ij}^2/\lambda_j}{\sum_{j=1}^{k} w_{ij}^2/\lambda_j} + \frac{\left(-\sum_{j=k^*+1}^{k} w_{ij}\beta_j^c\right)^2}{\sigma^2 T^{-1}\sum_{j=1}^{k} w_{ij}^2/\lambda_j}.$$

Equation (16) is seen to be the sum of the variance of b^*_i relative to the variance of b_i and of the (bias b^*_i)^2 relative to the variance of b_i.

Given a population relation as in equation (1), the effect of the bias on the relative mean square error of b^*_i to b_i is less, the smaller the sample size (smaller T) and the smaller the R^2 (the greater the σ^2).[2] In addition, highly multicollinear data result in one or more components having very small characteristic roots. Due to the bounds on the w_{ij}, one or more estimates b^*_i of β_i may have greatly reduced variances relative to OLS estimates.

The variance of b_i can be written in the following illustrative form (see Theil, p. 166):

$$(17)\quad \text{var } b_i = \sigma^2[(1 - R_i^2)X'_iX_i]^{-1},$$

where R_i^2 is the coefficient of determination corresponding to the linear regression of X_i on the remaining explanatory variables. As the linear relation (multicollinearity) between X_i and the remaining variables becomes more severe, R_i^2 approaches one and var b_i increases without bound. In this sense, the effect of the second term in equation (16) may be small.

In general, the CRC is more favorable in situations characterized by small sample size, low R^2, and high multicollinearity. A consistent estimate of the MSE of b^*_i relative to b_i is available by inserting the appropriate OLS estimates of b^c and σ^2 into equation (16).

t-Value Criterion

The inherent lack of control on the bias introduced when deleting components on the basis of the CRC suggests possible advantages in using a deletion criterion that tests the statistical significance of the regression coefficients b^c before deletion. A simultaneous testing procedure of the Bonferroni type based on the t-distribution might be used to test the null hypothesis that $\beta_j^c = 0$ for $j = 1, \ldots, k$.[3] The PC-OLS estimate of the β vector, using the TVC for deletion, is

$$(18)\quad b^* = WI_{(\tau)}b^c,$$

where $I_{(\tau)} = I - [I_{(-\tau_j, \tau_j)}(b_j^c)]$ is a $k \times k$ diagonal matrix, I is the $k \times k$ identity matrix, $\tau_j = t_j(s^2(T\lambda_j)^{-1})^{1/2}$, $j = 1, \ldots, k$, t_j is the critical t-value of the jth hypothesis test, s^2 is the square of the standard error of the equation, $I_{(a,\,b)}(X)$ is the indicator function (Mood, Graybill and Boes, p. 20),[4] and $[I_{(-\tau_j, \tau_j)}(b_j^c)]$ is

[2] The R^2 coefficient is used in the nonstochastic X case as a purely descriptive measure.

[3] The univariate t-test is applied to each component regression coefficient separately. Using the Bonferroni inequality, the simultaneous confidence coefficient applicable to the k univariate tests exhibits the lower bound $1 - \sum_{i=1}^{k}\alpha_{ti}$ where α_i is the probability of type I error for the ith univariate test.

[4] Essentially,

$$I_{(a,\,b)}(X) = \begin{cases} 1 \\ 0 \end{cases} \text{ when } \begin{cases} a < X < b \\ \text{otherwise} \end{cases}.$$

a $k \times k$ diagonal matrix, exhibiting the indicator functions for $j = 1, \ldots, k$ on the diagonal.

Equation (18) indicates that the deletion of components depends upon the τ_j, which are in turn functions of the stochastic variable s^2 and of the chosen critical t-values. Specifically, a column vector of W is transformed to the zero vector whenever its associated regression coefficient b_j^c is judged not significantly different from zero using the t-test. The expected value of the ith entry of b^* is

$$(19)\quad Eb^*_i = \sum_j w_{ij} \int_0^\infty \left(\int_{-\infty}^{-\tau_j} b_j^c f_j(b_j^c)\mathrm{d}b_j^c + \int_{\tau_j}^{\infty} b_j^c f_j(b_j^c)\mathrm{d}b_j^c \right) g(s^2)\mathrm{d}s^2,$$

where

$$f(b^c, s^2) = \left(\prod_{i=1}^{k} f_i(b_i^c) \right) g(s^2);$$

that is, the joint density function of b^c and s^2 is the product of the marginal density functions, since all the b_i^c are distributed independently (being distributed normally, with zero covariances), and the b^c vector is distributed independently of s^2 (see Dhrymes, pp. 149–50).

The bias of b^*_i can be written as

$$(20)\quad \text{bias } b^*_i = Eb^*_i - \beta_i = -\sum_j w_{ij} \int_0^\infty \int_{-\tau_j}^{\tau_j} b_j^c f(b_j^c) g(s^2)\mathrm{d}b_j^c\mathrm{d}s^2.$$

Letting $t_j = t$ for all j, as $t \to \infty$, the bias b^*_i approaches $-\sum_j w_{ij}\beta_j^c$, and as $t \to 0$, the bias b^*_i approaches zero.[5]

The covariance matrix of b^* is

$$(21)\quad E(b^* - Eb^*)(b^* - Eb^*)' = E(WI_{(\tau)}b^c - WE(I_{(\tau)}b^c))(WI_{(\tau)}b^c - WE(I_{(\tau)}b^c))' = W[E(I_{(\tau)}b^c b^{c\prime} I_{(\tau)}) - E(I_{(\tau)}b^c)E(b^{c\prime} I_{(\tau)})]W'.$$

A typical diagonal element of equation (21) can be written as

$$(22)\quad \text{var } b^*_i = \sum_j \sum_k w_{ij}w_{ik} \left(\int_0^\infty \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} (1 - I_{(-\tau_j, \tau_j)}(b_j^c))(1 - I_{(-\tau_k, \tau_k)}(b_k^c)) b_j^c b_k^c f(b_j^c) \cdot f(b_k^c) g(s^2)\mathrm{d}b_j^c\mathrm{d}b_k^c\mathrm{d}s^2 - E((1 - I_{(-\tau_j, \tau_j)}(b_j^c))b_j^c)E((1 - I_{(-\tau_k, \tau_k)}(b_k^c))b_k^c) \right).$$

When t is in the neighborhood of zero, the var b^*_i is close to the var b_i, and as t becomes extremely large and increases without bound, var b^*_i approaches zero.[6]

Unfortunately, it is not necessarily true in the case of the TVC that the var $b^*_i \leq$ var b_i. The variance of the component estimator may actually be greater than the variance of the OLS estimator. This possibility is illustrated by a Monte-Carlo experiment presented in the next section, which includes cases where var $b^*_i >$ var b_i for some i.[7]

The relative MSE of the TVC estimator compared with the OLS estimator can be written in a general way as

$$(23)\quad \frac{\text{MSE } b^*_i}{\text{MSE } b_i} = \frac{\text{var } b^*_i}{\text{var } b_i} + \frac{(\text{bias } b^*_i)^2}{\text{var } b_i},$$

where the var b^*_i and bias b^*_i are given by equations (22) and (20), respectively. The TVC does not lend itself to a general discussion of the behavior of the estimates under varying sample sizes, degree of multicollinearity, or level of R^2 primarily because the expressions for the variances of b^*_i are extremely complicated.

Nonetheless, a few general comments can be made concerning the use of the TVC in forming PC-OLS estimates. First, the control on the bias b^*_i becomes relatively less important the higher the degree of multicollinearity, given that X_i is involved in the multicollinearity problem in a general way (recall equation (17)). Second, it is discomforting to know that the relative variance ratio in equation (23) may be greater than one, indicating that TVC-derived PC-OLS estimates would not only be biased but would have greater variance than the OLS estimates. Lastly, it is not clear what critical value of t should be used, nor whether a different critical value of t should be used for each coefficient test.

A Monte-Carlo Experiment

A Monte-Carlo experiment was conducted to examine the behavior of the TVC criterion using a conventional t critical value set at the 0.05 level of significance. A lower value of the t critical value is also examined. The CRC

[5] The behavior of the bias b^*_i between the extreme limits for t is not generally monotonic, due to the fact that the individual integrals in equation (20) may converge at differing rates.

[6] The behavior of the variance of b^*_i between the extreme limits for t will not be monotonic, in general, due to the fact that the individual integrals in the sum in equation (22) may converge at different rates.

[7] The authors have tried in vain to construct a general proof of the possibility that var $b^*_i >$ var b_i. The difficulty is that the variance expressions as equation (22) do not have solutions in closed form.

estimator is included in the experiment for comparison purposes. The function to be estimated under the differing criteria is specified as $Y = -42 + 10X_1 + 27X_2 + 36X_3 + 4X_4 + U$. The values of the parameters are arbitrarily selected. The mean values for the X's are selected randomly from the integers 1 to 100 and their variances established at one-fourth of their means. Three sets of zero-order correlation coefficients are selected to represent varying degrees of collinearity. For a given set of correlation coefficients, an X matrix of twenty-five observations is selected. Then, for each X matrix and for an $R^2 = 0.90$, 500 different Y vectors of twenty-five observations each are generated. The procedure is duplicated for $R^2 = 0.50$.

The three X matrices are fixed in repeated sampling. The correlation matrices of X are orthogonalized by the appropriate matrix of characteristic vectors (W). A new set of variables is then formed for each X matrix using $Z = XW$ (recall equation (2)); and for each of the 500 Y vectors, a regression equation is estimated.

The characteristic vectors corresponding to those characteristic roots whose values are less than the value established as the deletion criterion are replaced with zeros. As in equation (6), the b^c are transformed to the original frame of analysis, giving the vector of PC-OLS estimates b^*. This is done for 500 samples with two different characteristic root criteria equal to 1.00 and 0.50.[8]

Similarly, for the same 500 samples, regression coefficients of the principal components are set to zero when the null hypothesis $\beta_j^c = 0$ cannot be rejected. The t-value deletion criteria are first set at $t = 2.0860$, which for twenty degrees of freedom represents a 0.95 confidence interval for each univariate test, for a simultaneous confidence coefficient greater than or equal to 0.80. A t of 1.0000 is also used, implying a simultaneous confidence coefficient greater than or equal to 0.36. The new vector b^{*c} is then transformed back to the original frame of reference: $b^* = WI_{\sigma}b^c$.

For each criterion and for each of the given estimated coefficients, three summary statistics are developed. First, the standardized bias of b^*_i is calculated as $(\bar{b}^*_i - \beta_i)/\sigma_{b_i}$, where $\bar{b}^*_i = \sum_l b^*_{l,i}/500$, the summation is over 500 observations, and σ_{b_i} represents the true OLS standard deviation of the specified population parameter estimate.

The second calculation involves the ratio of the variance of each b^*_i about its empirical mean in relation to the true OLS variance, $\sigma_{b_i}^2$: $\sum_l (b^*_{l,i} - \bar{b}^*_i)^2/499\sigma_{b_i}^2 = s_{b^*_i}^2/\sigma_{b_i}^2$.

Lastly, the empirical mean square error of each b^*_i is compared with the true OLS variance of b_i, that is, $(s_{b^*_i}^2 + (\text{bias } b^*_i)^2)/\sigma_{b_i}^2$. The results generated from the experiment are too numerous to be presented here in full. Hence, the following descriptive statistics are used to facilitate a discussion of the results: average absolute value of the standardized bias (AASB): $AASB = \sum_{i=1}^{k} |\text{standardized bias}_i|/k$; average relative variance (ARV): $ARV = \sum_{i=1}^{k} (\text{var } b^*_i/\text{var } b_{i,\,OLS})/k$; average relative mean square error (ARMSE): $ARMSE = \sum_{i=1}^{k} (\text{MSE } b^*_i/\text{var } b_{i,\,OLS})/k$.

Results of the Monte-Carlo Experiment

The two criteria of component deletion, CRC and TVC, behave quite differently and distinctly under different levels of multicollinearity (table 1). As discussed in the section on the characteristic root criterion, the CRC does not take the bias into account when deleting components. The TVC, on the other hand, does account for bias in the sense of testing the significance of component coefficients before a decision concerning deletion is made. The results in table 1 exhibit the consequences vividly, where the CRC produce in the aggregate sense more biased estimates than estimates using the TVC.[9] This result was typical for the estimates of the individual β_i (which are not all presented here).

[8] A characteristic root of $\lambda = 1$ can be thought of as the average value of a characteristic root when a correlation matrix is factorized: $\text{tr}\Omega = T^{-1}\text{tr}(X'X) = T^{-1}\text{tr}(X'XWW') = T^{-1}\text{tr}(W'X'XW) = T^{-1}\text{tr}(Z'Z) = \text{tr}\Lambda = \sum_{i=1}^{k} \lambda_i$, and since $\text{tr}\Omega = k$, the average characteristic root is $1 = \sum_{i=1}^{k} \lambda_i/k$. Then, using this CRC, a component is deleted if it has a below-average characteristic root. Further discussion of the $\lambda = 1$ deletion criterion can be found in Rummel, pp. 357–65.

[9] The results in the highly multicollinear case are identical for $\lambda = 1$ and $\lambda = 0.5$, since one component accounts for 91.80% of the variation and has a characteristic root equal to 3.67. Clearly, the other three characteristic roots are all less than 0.5, and so the same number of components are deleted under each criterion.

Table 1. Summary of Results from Monte-Carlo Study

	$R^2 = 0.90$			$R^2 = 0.50$		
	AASB	ARV	ARMSE	AASB	ARV	ARMSE
High collinearity[a]						
CRC $\lambda = 1.0000$	1.1383	0.1725	2.3799	0.3916	0.1836	0.4092
CRC $\lambda = 0.5000$	1.1383	0.1725	2.3799	0.3916	0.1836	0.4092
TVC $t = 2.0860$	0.3097	1.0655	1.2023	0.2540	0.5346	0.6352
TVC $t = 1.0000$	0.0764	0.9910	0.9979	0.0561	0.9232	0.9287
Moderate collinearity						
CRC $\lambda = 1.0000$	1.8241	0.2383	5.9991	0.6156	0.2309	1.1850
CRC $\lambda = 0.5000$	1.8709	0.4183	6.2225	0.6240	0.4040	1.0555
TVC $t = 2.0860$	0.4274	1.6693	1.9502	0.3200	0.8615	1.0522
TVC $t = 1.0000$	0.0782	1.1120	1.1209	0.0672	1.0252	1.0320
Low collinearity						
CRC $\lambda = 1.0000$	3.0560	0.3868	10.5683	1.0220	0.3813	1.5115
CRC $\lambda = 0.5000$	2.7041	0.6141	10.8966	0.8783	0.6124	1.6096
TVC $t = 2.0860$	0.4779	1.3845	1.5656	0.5736	1.0589	1.4288
TVC $t = 1.0000$	0.0605	1.1053	1.1112	0.1384	1.0876	1.1123

[a] High collinearity: $|\Omega| = 0.0045$, $r_{12} = 0.87$, $r_{13} = 0.89$, $r_{23} = 0.91$, $r_{14} = 0.87$, $r_{24} = 0.89$, $r_{34} = 0.91$. Moderate collinearity: $|\Omega| = 0.0930$, $r_{12} = 0.59$, $r_{13} = 0.59$, $r_{23} = 0.63$, $r_{14} = 0.78$, $r_{24} = 0.74$, and $r_{34} = 0.54$. Low collinearity: $|\Omega| = 0.6647$, $r_{12} = 0.34$, $r_{13} = -0.03$, $r_{23} = 0.44$, $r_{14} = -0.02$, $r_{24} = 0.15$, and $r_{34} = 0.13$. Ω is the correlation matrix of X.

With decreasing levels of multicollinearity, the AASB increases using the CRC (table 1). This occurs under conditions of high and low R^2. Particularly distressing is the erratic nature of the bias using the CRC under high R^2 and lower collinearity. Some of the individual estimates were biased to the extent that they were many standard deviations from β_i.

Recalling equations (12) and (13), the CRC does, however, take into account the denominators of the terms in the sum producing the variance expression. Extremely low values of some of the characteristic values, as would be the case in highly collinear situations, coupled with moderate w_{ij}^2 values could result in large gains in precision when deleting components. On the other hand, there is no guarantee that when using the TVC the estimates are more precise than OLS estimates.[10] Again, the results in table 1 exhibit an interesting contrast between CRC and TVC. The CRC yields quite precise estimates relative to the TVC. Under conditions of high or low R^2, the CRC produces an ARV well below unity. As the degree of collinearity decreases, so does the savings in precision as the characteristic roots associated with deleted components increase in magnitude. The TVC, however, generally performs poorly except in the case of high collinearity and low R^2. The individual estimates of β_i using CRC typically had lower variance than the TVC.

As a measure of the relative MSE of CRC and TVC estimates compared with OLS estimates, recall

$$\frac{\text{MSE } b^*_i}{\text{MSE } b_i} = \frac{(\text{bias } b^*_i)^2 + \text{var } b^*_i}{\text{var } b_i}$$

$$= (\text{standardized bias } b^*_i)^2 + \frac{\text{var } b^*_i}{\text{var } b_i}.$$

With the exception of the case of high collinearity and low R^2, the MSE of CRC is greater than the MSE of either TVC or OLS. As the degree of collinearity decreases, the ARMSE of CRC increases. This is particularly true for the case of high R^2. Under the TVC, particularly with $t = 1$, a relatively small bias is introduced, but little precision is gained. This results in estimates that generally exhibit greater MSE than OLS estimates. When R^2 is low and the collinearity high, both the TVC and the CRC have smaller MSE than OLS (table 1).

Table 2 presents in more detail the case

[10] Recall the discussion in the section on t-value criterion. The expression for the variance when using TVC is expressed in symbolic form in equation (22). The explicit expression is an extremely complicated function of the normal and gamma density functions and the critical t-value and is not presented here.

Table 2. Results of Monte-Carlo Experiment with $R^2 = 0.50$ and Sample Generalized Variance = 0.0045

Parameter	Criterion	$\bar{b}^*_i$	STD b^*_i	$\frac{\text{MSE } b^*_i}{\text{MSE } b_i}$
β_1	OLS	10.0	45.2	1.00
	$\lambda = 1.0, 0.5$	23.9	4.8	0.11
	$t = 2.086$	20.6	24.2	0.34
	$t = 1.0$	11.2	41.2	0.83
β_2	OLS	27.0	19.0	1.00
	$\lambda = 1.0, 0.5$	9.3	1.9	0.88
	$t = 2.086$	15.5	15.8	1.06
	$t = 1.0$	24.6	18.9	1.01
β_3	OLS	36.0	141.9	1.00
	$\lambda = 1.0, 0.5$	61.5	12.3	0.04
	$t = 2.086$	56.6	78.0	0.32
	$t = 1.0$	50.0	134.6	0.91
β_4	OLS	4.0	263.6	1.00
	$\lambda = 1.0, 0.5$	129.0	25.9	0.23
	$t = 2.086$	68.3	193.4	0.60
	$t = 1.0$	6.9	255.8	0.94

Note: Deletion using either $\lambda = 1.0$ or $\lambda = 0.5$ in this case results in identical estimators (see footnote 9). Simple correlations in this case are $r_{12} = 0.87$, $r_{13} = 0.89$, $r_{23} = 0.91$, $r_{14} = 0.87$, $r_{24} = 0.89$, and $r_{34} = 0.91$.

where PC-OLS exhibits its best performance—the case of low R^2 and high multicollinearity. Except for the estimates of β_2 using the TVC, the MSE's of PC-OLS estimates are lower than the MSE's of OLS estimates.

However, although PC-OLS appears to be better than OLS in the relative MSE sense, there is a question of whether or not any of the estimating procedures result in acceptable estimates; that is, the MSE of a PC-OLS estimate, although small relative to the MSE of an OLS estimate, may still be large in an absolute sense and may contain a large variance and/or bias component.[11] A case in point is the TVC estimate of β_4 using a t-value of 1.0, which exhibits an extremely large variance, although it is better than OLS in the relative MSE sense.

Summary and Recommendations

This particular simulation study and certain theoretical considerations indicate that the principal components regression technique does not perform well when R^2 is high and/or collinearity is low. In this case, estimates produced under the CRC, although more precise than OLS estimates, are biased to the extent that they have larger MSE's than OLS estimates. The TVC generally produces less biased estimates than CRC in this situation, although the gain in precision, if any, is less than when using the CRC. This also results in estimates that, for the most part, have larger MSE's than OLS but smaller MSE's than the CRC. Under conditions of high collinearity and low R^2, either the CRC or the TVC appear to produce more precise estimates with lower MSE's than OLS. The CRC produces estimates with lower variance but greater bias than TVC estimates.

Although in certain cases the PC-OLS estimates may be better than OLS estimates in the MSE sense, they may still be unsatisfactory in the absolute sense. Most of the individual parameter estimates for the cases where PC-OLS exhibits its best performance in terms of relative MSE still have large variances and/or large biases.

While this study does not provide a complete investigation of principal components regression technique using either CRC or TVC, it does demonstrate that this technique is not a panacea for highly collinear data. The PC-OLS estimation technique using either CRC or TVC does not provide a general remedy for the multicollinearity problem. On the other hand, the fact that PC-OLS estimates outperform OLS estimates in terms of MSE in certain situations suggests that the technique cannot be generally considered inappropriate as an alternative to OLS. Judicious application of the PC-OLS technique, as with most biased techniques, would require a priori notions of signs and relative magnitudes of parameter values that could be used to judge the reasonableness of estimates.

It is hoped that by discussing the mechanics of CRC and TVC deletion in PC-OLS estimation, and by presenting some of the strengths and weaknesses of the technique, the applied researcher is better able both to interpret the results of studies using this technique and to judge whether or not the technique would be useful in his own research.

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[11] Max R. Langham brought this important point to our attention.

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Linear Programming versus Positively Estimated Supply Functions: An Empirical and Methodological Critique

C. Richard Shumway and Anne A. Chang

This paper examines whether supply relations derived from a static profit-maximizing linear programming model can be used as information to explain supply response with at least the same reliability as partial adjustment regression models. Programming estimates of direct supply elasticities of California commodities are compared with estimates from time-series regressions. Differences on individual crops are considerable, but on average the elasticity estimates are comparable. Programming parameters are combined with time-series data to test whether imposing such relative parameters on time-series models need not significantly reduce their predictive ability. This imposition does not reduce predictive ability or significantly improve it.

Key words: linear programming, prediction, regression, supply functions.

This paper evaluates the reliability of linear programming (LP) as a method of estimating supply elasticities and predicting future production levels in a situation where econometric tools are viable alternative methods. LP and positive estimates of the long-run supply functions for fifteen major vegetables and field crops in California are developed for an approximately comparable historical time period. Both direct (i.e., own product) and cross- (i.e., alternative product) price relationships are estimated via LP, but only direct relationships are estimated with single-commodity partial adjustment equations.

After developing both sets of supply relationships, their long-run direct elasticity estimates are evaluated for mean comparability. Subsequently, the LP direct and cross-price parameters are combined with time-series data to test the hypothesis that the imposition of the relative magnitudes of the LP parameters on a time-series regression supply model need not significantly reduce its ability to predict future output levels. Before addressing these objectives, it is useful to digress briefly to outline the basic problem that compels such attention.

Status of Research on Cross-Price Supply Relations

Accurately estimating the responsiveness of commodity supply to price changes is both important and extremely difficult. Much research effort has been devoted to supply analysis using both positive and conditionally predictive estimating procedures.[1] However, most of this work has been concerned with the development of single-commodity supply functions with little explicit regard for the effect of other commodity prices.

While important conceptual and empirical problems remain in understanding direct price effects on supply, even more serious problems limit the understanding of cross-price relationships. Relatively little empirical research has addressed the estimation of cross-price parameters in the supply function. One of the few exceptions is the pioneering work of Pow-

C. Richard Shumway is an associate professor and Anne A. Chang is a research assistant in the Department of Agricultural Economics, Texas A&M University.

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[1] Supply relations that are derived from continuous or stepped production functions by assuming profit-maximizing behavior on the part of producers is given several different labels in the literature, e.g., normative, conditionally normative, and conditionally predictive. Preference for the terminology "conditionally predictive," used in this paper, is originally defended by Hildreth and Castle (pp. 31–32).

ell and Gruen, who imposed the assumption of a constant elasticity of transformation on the production function to reduce the number of supply parameters requiring estimation. Assuming profit-maximizing behavior, conditionally predictive estimates of direct and cross elasticities of supply in Australia were developed for six commodities from time-series data (Gruen et al.).

Among the positive estimates, Just's econometric analysis of eight California field crops is perhaps the most comprehensive. Yet, no more than two alternative product price variables are included in any of his empirical equations.

What is most striking is that the number of conditionally predictive estimates of cross-price relationships derived from LP is also very limited. The S-42 Technical Committee's publication on cotton reports the estimated impact of price changes for one agricultural commodity on the supply of several other commodities. Most other major LP supply studies that have included alternative commodities are limited in focus to no more than two cross-price relationships (e.g., Colyer and Irwin; Helmers and Lagrone; Dean, Johnson, and Carter).

LP is seemingly an obvious analytical approach for comprehensive estimation of cross-price effects because it is a controlled synthetic experiment. Interaction between a wider range of alternative products and production processes than is practical in time-series analyses can be considered. By carefully selecting the manner in which variables are parametrized, the major data problem that plagues positive estimation of cross relationships, i.e., high correlation among independent variables, can be avoided.

Evidence of Unreliability in Conditionally Predictive Estimates

There is little empirical evidence that reliable direct price relationships, let alone cross-price effects, can be estimated with conditionally predictive models, including LP. For example, in a comparative study of supply estimates derived from production functions versus positive estimates, Wipf and Bawden find that (*a*) "Output predictions obtained from the derived supply approach (from production functions) do not exhibit a consistent magnitude or direction of bias—they range from slight under-estimates to extreme over-estimates of actual output, with the latter being the most prevalent" and (*b*) "Both casual observation and directly estimated (positive) supply equations show firms to be less responsive to price changes than indicated by supply elasticities derived from production functions" (p. 177). In a comparison of selected LP supply elasticity estimates with positive time-series estimates for three subsectors, Quance and Tweeten also observe greater variability and generally larger magnitudes in the conditionally predictive than in the time-series elasticity estimates. They conclude that "the LP models are more realistic for showing regional shares of production (based on comparative advantage) than for showing the absolute level and elasticity of supply" (p. 7).

The issue of evaluating reliability is fundamental since it is generally easier to obtain estimates of cross-price supply relationships from conditionally predictive models, especially LP, than from positive models. However, before placing confidence in LP cross-price estimates, one must first be convinced that the direct price estimates are reliable.

Methodological Critique

It is intuitively apparent that estimates obtained from positive time-series models differ from those derived from LP, but it is not apparent a priori that the positive estimate should in all cases be more reliable than the LP estimate. Because the positive estimate is based on fitting a linear regression to historical data with least-squared error, one expects it to describe what has actually occurred in the past and, if past policies and relationships among variables remain stable, to predict more accurately than the LP-derived estimate. Positive estimates may neither accurately describe the past nor accurately predict if one or more of the standard statistical assumptions are violated, e.g., errors in data measurement or aggregation, high correlation among independent variables, omission of relevant variables, or incorrect anticipation of the form of the relationship.

In contrast, using a combination of historical and synthetic data and imposing a behavioral assumption (typically profit maximization), linear programming describes what "should" have happened rather than what did happen. Perhaps its most important strength is that it can simulate the effects of exogenous forces and policies for which historical obser-

vations are not available. But problems faced with LP in either correct description or prediction are also substantial (Stovall). Much of the data necessary for LP supply model development, e.g., crop budgets and resource restraints, are difficult to adequately verify external to the model. Data validity can often be tested only indirectly by comparing initial model results with a historical referent. It is difficult to prevent important aggregation errors when cumulating representative farm LP results. Since profit maximization is not the only goal of producers, models that fail to consider risk and nonmonetary objectives in the analysis may abstract seriously from reality. Due to the stepped nature of the LP production function, it is possible to obtain perfectly elastic or inelastic estimates of supply over small price ranges.

Although LP analyses abstract from reality, the question remains whether their previously noted unreliability in estimation is inherent in either their synthetic nature or behavioral assumption or whether it is due to the particular examples cited.[2] In the Wipf and Bawden and Quance and Tweeten comparative studies of conditionally predictive and positive supply estimates, the commodity comparisons are limited, the spatial and temporal dimensions of the models not entirely comparable, and the analyses rather casual. Consequently, the current analysis develops both positive and LP estimates of the supply relations for a large number of commodities in the same geographic region and for essentially the same time period.

Linear Programming Estimation

Model Formulation

Static LP resource allocation models were developed previously for California (Shumway et al.). The state is divided into ninety-five homogeneous production areas based on similarities in soil, climate, and water resources. Acreage suitable and potentially available for crop production in each production area during the period 1961–65 is inventoried. Estimates of per acre yield and non-land production costs for each of fifteen commodities and commodity groups, representing 79% of total crop acreage, are developed for each area for that period. Acreage in excluded high-value crops (orchard crops and minor vegetables) and in nonagricultural uses is deducted from the acreage inventory. Maximum individual crop acreages are limited only by land and water resources available and by rotation requirements. Hence, production changes are permitted within a long-run firm adjustment period with constant technology—no short-run restraints such as capital, farm size, labor, or management are imposed.

The objective function of the model is converted from cost minimization to profit maximization with product and nonland input prices given so that the parametrization could be performed on the independent supply variable, price. Based on the premise that expected price in any year is equal to lagged actual price, production costs are adjusted so that constrained model results approximate actual 1961–65 output of each commodity at 1960–64 prices.[3] Parametric programming is then applied to chart the effect of alternative prices on output levels.

The total land resource available for producing the fifteen commodities/commodity groups is assumed to be limited at the model's requirement for average 1961–65 output of these commodities. Actual harvested acreage of these crops during 1961–65 is less than in some years prior to 1955 but approaches the upper limit on subsequent acreage harvested. Beginning with actual 1960–64 average prices for all commodities, one price is parametrically changed by intervals of approximately one-tenth of the difference between high and low deflated prices during 1950–73.[4] This procedure is repeated by parametrically increasing and decreasing the price of each commodity in sequence while holding all other prices constant. Thus, observations of price changes for each commodity and derived optimal output levels for all fifteen commodities are obtained.

The parametric programming results are treated as though they are independent obser-

[2] Considerable attention has been devoted in recent years to methods for making programming models produce results more in line with results observed in the real world. These efforts have included incorporation of flexibility constraints into recursive linear programming systems (e.g., Shaller and Dean) and specification of more realistic behavioral properties (e.g., Boussard, Boussard and Petit). The scope of this paper, however, is confined to an evaluation of results obtained only from more conventional static profit-maximizing LP.

[3] Production cost budgets representing approximately the top 20% of producers are scaled upward across production areas for each commodity.

[4] California product prices (California Crop and Livestock Reporting Service, all dates) are deflated by the USDA (1973, 1974) index of prices paid by farmers for inputs (1960–64 = 100).

vations.[5] Because of the sequential nature in which prices are changed, the data are segmented and simple linear regressions of output are fit to relevant data subsets in which the price of only one commodity varied:

$$(1) \qquad Y_i = a_{i0} + a_{ij}P_j + \mu_{ij},$$

where Y_i is the derived output vector of commodity i, P_j is the parametrized price vector for commodity j (all other prices held constant), and μ_{ij} is the disturbance term. At the suggestion of one of the reviewers, output is also regressed as a quadratic function on own price:

$$(2) \qquad Y_i = a_{i0} + a_{ii}P_i + \alpha_{ii}P_i^2 + \mu_{ii}.$$

$\bar{R}^2$ values of the own price equations are improved in most cases by inclusion of the quadratic term.

LP-Derived Elasticity Estimates

Estimates of the long-run supply elasticities for each commodity/commodity group are computed at the average 1961–65 output levels and lagged representative crop prices, which are listed in table 1. These conditionally predictive direct and cross-price elasticity estimates are reported in table 2. Except for cotton, all direct elasticities derived from the linear equations exceed 1.0, and most are considerably higher. The direct elasticities derived from the quadratic equations are typically greater than those from the linear equations. Cross elasticities are positive only between barley price and grain sorghum supply, grain sorghum price and barley supply, and broccoli price and lettuce supply. These crops are frequently doublecropped so positive cross elasticities are reasonable. Both direct and cross elasticities tend to be higher for commodities with relatively small 1961–65 acreages (i.e., all vegetables, corn, and sugar beets). These estimates are probably overestimated due to the aggregate nature of the model. Although there are up to ninety-five segments on the model's stepped production function for each commodity, each step may be very large for the smaller crops. Therefore, we have less confidence in the reasonableness of the LP elasticity estimates for the minor than for the major crops.

To determine whether the extremely elastic

[5] The use of regression analysis is reported here with two qualifications: (*a*) the observations are not really independent since prices are not selected randomly and (*b*) the price selection procedure implies a uniform distribution of prices between the high and low observations. Since the typical distribution of actual prices is more bell-shaped, use of the parametric programming observations here gives undue weight to the outliers.

Table 1. Average 1961–65 Output and 1960–64 Price of California Vegetables and Field Crops

Representative Commodity (Commodity Group)	Commodity (Commodity Group) Output, Average 1961–65[a] (1,000 Units)	Representative Commodity Price, Average 1960–64 ($/Unit)
Alfalfa hay (ton)	6,223	24.38
(and seed)	(6,837)	
Barley (ton)	1,755	45.15
(small grains)	(2,509)	
Corn for grain (ton)	240	50.42
(and silage)	(405)	
Cotton (bale)	1,749	164.74
Dry beans (ton)	158	192.93
Grain sorghum (ton)	494	42.62
(and sorghum silage)	(522)	
Rice (ton)	765	97.21
Safflower (ton)	257	84.27
Sugar beets (ton)	5,866	11.54
Asparagus (ton)	95	261.06
Broccoli (ton)	85	158.97
(cole crops)	(151)	
Cantaloupes (ton)	342	87.04
(melons)	(512)	
Lettuce (ton)	1,141	75.87
Potatoes (ton)	1,518	46.97
Tomatoes, processing (ton)	2,694	26.38
(and fresh)	(3,333)	

[a] See Shumway et al. for procedure used to convert commodity group output data to representative crop units.

Table 2. Conditionally Predictive Estimates of Long-Run Elasticities of Supply, Initial Data

Commodity	No.	Linear Function, Elasticity with Respect to the Price of															Quadratic Function, Own Price Elasticity
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Alfalfa hay (and seed)	1	5.3	−2.1	−0.8	−0.1	−0.1	−0.6	−0.5	−0.3	−1.6	−2.5	−1.8	−1.2	−2.8	−0.4	−1.3	11.6
Barley (small grains)	2	−1.8	4.8	−1.0	0	−0.3	1.2	−0.8	0	−1.7	−1.7	−0.9	−1.5	−1.6	−0.1	−0.9	5.0
Corn for grain (and silage)	3	−2.8	−2.6	23.1	0	−0.2	−0.7	0	0	−2.6	−1.2	−1.7	0	−1.8	−0.4	−0.8	56.8
Cotton	4	−1.3	−0.8	−0.7	0.8	−0.2	−0.3	−0.6	−0.6	−0.5	−0.7	−1.5	−1.5	−2.2	−0.3	−0.6	2.1
Dry beans	5	−2.0	−1.3	−1.0	−0.3	4.0	−0.7	0	−0.2	−2.5	−2.1	−2.5	−0.9	−2.2	−0.6	−1.2	14.1
Grain sorghum (and sorghum silage)	6	−1.1	7.1	−0.2	0	0	9.6	0	−0.1	0	−1.4	0	0	0	0	−0.3	17.9
Rice	7	−1.0	−2.6	−0.5	0	−0.4	−0.4	6.0	0	−2.9	−1.8	0	−1.3	−1.2	0	−1.3	8.5
Safflower	8	−0.1	0	0	0	0	0	0	8.3	0	0	0	0	0	0	0	7.6
Sugar beets	9	−1.5	−1.2	−1.0	−0.1	−0.4	−0.7	−0.3	0	30.3	−2.3	−2.1	−0.7	−2.1	−0.2	−1.6	24.4
Asparagus	10	−1.5	−0.8	−1.5	0	−0.2	−0.7	0	0	−2.0	142.5	−2.3	0	−1.8	−0.8	−1.2	180.0
Broccoli (cole crops)	11	−4.3	−1.0	−1.8	−0.8	−0.3	−0.8	0	0	−6.0	−3.3	117.9	−0.8	−5.4	−1.0	−3.4	61.8
Cantaloupes (melons)	12	0	0	0	0	0	0	0	0	0	0	0	67.9	0	0	0	203.1
Lettuce	13	−1.5	−0.4	−1.0	0	0	−0.5	0	0	−3.5	−1.1	8.1	0	116.6	−0.6	−0.9	91.6
Potatoes	14	−1.3	−0.3	−0.5	0	0	0	0	0	−0.8	−1.0	−1.0	0	0	15.9	−0.8	54.7
Tomatoes, processing (and fresh)	15	−2.2	−2.3	−1.3	0	−0.1	−0.6	0	−1.9	−2.0	−2.9	−1.6	−0.2	−1.5	−0.4	25.3	54.7

supply functions for crops with smaller acreages is a local phenomenon of the LP model structure in the vicinity of 1960–64 prices, their price ranges are widened arbitrarily to five times the 1950–73 range. Ten additional observations of crop output are obtained by further parametric price changes for each of these eight crops over the expanded range. Regression equations are reestimated from this expanded data set, and elasticities are again computed at mean 1961–65 output levels and lagged prices. The results are reported in table 3.

Direct elasticities for crops with expanded price ranges are substantially lower in all cases than previously for both linear and quadratic formulations, suggesting that the high elasticities are due at least in part to the limited range of prices considered. The direct linear estimates now range from 0.8 to 9.6, as compared with a range from 0.8 to 142.5 previously. The direct quadratic estimates are now 1.2 to 29.8, as compared with 2.1 to 203.1 previously.

Positive Estimation of Direct Supply Relationships

Model Formulation

Using annual time-series data for 1950–73 (i.e., the same data as previously used to specify the initial range for the LP parametric analysis), a simple partial adjustment supply model is hypothesized for each of the fifteen representative commodities:

$$(3) \qquad y_t = b_0 + b_1 p_{t-1} + b_2 y_{t-1} + \mu_t,$$

where y is output, p is product price deflated by the index of prices paid for inputs, t is year, and μ is the disturbance term. Recognizing that the output of some commodities has changed markedly over the twenty-four-year period due to technology and other changes, a second model that includes a trend variable is also estimated:

$$(4) \quad y_t = b_0 + b_1 p_{t-1} + b_2 y_{t-1} + b_3 t + \mu_t,$$

where t is year (1950 = 1).

Since an in-depth investigation of the supply relationships for each crop was not conducted, it is unlikely that all supply systems are adequately explained by either of these model structures. Therefore, in lieu of hypothesizing and testing many other alternative models, rather rigorous conditions are specified for accepting these models as adequate explanatory structures, and the empirical evaluation of direct elasticities is restricted to those equations that are not rejected. Only those equations are considered for empirical evaluation that exhibit both parameter signs and magnitudes consistent with a priori expectations (i.e., $b_1 > 0$, $0 \leq b_2 < 1$) and b_1 coefficients significant at the 5% level. No preferential treatment is given to either model. If the empirical results of both pass the conditions, both equations are reported for that commodity. The average of their long-run direct supply elasticity estimates is compared with the linear programming estimates.

Equations in which the lagged dependent variable appears as an independent variable frequently exhibit serially correlated disturbance terms and also bias the test for serial correlation in OLS estimation. Consequently, the less restrictive Cochrane and Orcutt model with the Cooper transformation is used to obtain parameter estimates and standard statistics with asymptotically desirable properties for these equations.

Positive Elasticity Estimates

For nine of the fifteen commodities, at least one time-series regression equation satisfies the a priori conditions. Unsatisfactory results are obtained with both hypothesized models for the remaining six crops: alfalfa hay, grain sorghum, rice, safflower, asparagus, and processing tomatoes. The unsatisfactory results from these models are not surprising for the two perennial crops—alfalfa hay and asparagus. A more complex investment model is likely needed to adequately explain planting response for perennials. The poor showing of the partial adjustment models for the other four crops is also understandable. Rice and grain sorghum are produced under commodity programs, safflower appears during this period as an emerging agricultural industry, and production practices for processing tomatoes shifted midway through the time series from labor intensive to a mechanized harvest. (See Chern for a recent analysis of processing tomato supply response.)

For the other nine crops, the estimated parameters and long-run supply elasticity computed at average 1961–65 output and lagged price are reported in table 4 for satisfactory

Table 3. Conditionally Predictive Estimates of Long-Run Elasticities of Supply, Expanded Data

Commodity	No.	Linear Function, Elasticity with Respect to the Price of															Quadratic Function, Own Price Elasticity
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Alfalfa hay (and seed)	1	5.3	−2.1	0	−0.1	−0.1	−0.6	−0.5	−0.3	−0.1	−0.1	−0.1	0	−0.1	0	0	11.6
Barley (small grains)	2	−1.8	4.8	0	0	−0.3	1.2	−0.8	0	−0.1	−0.1	−0.1	0	0	0	−0.1	5.0
Corn for grain (and silage)	3	−2.8	−2.6	1.0	0	−0.2	−0.7	0	0	−0.1	0	−0.1	0	0	0	0	4.0
Cotton	4	−1.3	−0.8	−0.1	0.8	−0.2	−0.3	−0.6	−0.6	−0.2	−0.2	−0.1	0	0	0	−0.1	2.1
Dry beans	5	−2.0	−1.3	−0.1	−0.3	4.0	−0.7	0	−0.2	−0.2	−0.1	−0.1	0	−0.1	0	−0.1	14.1
Grain sorghum (and sorghum silage)	6	−1.1	7.1	0	0	0	9.6	0	−0.1	0	−0.1	0	0	0	0	0	17.9
Rice	7	−1.0	−2.6	0	0	−0.4	−0.4	6.0	0	−0.1	−0.1	−0.1	0	−0.1	0	0	8.5
Safflower	8	−0.1	0	0	0	0	0	0	8.3	0	0	0	0	0	0	0	7.6
Sugar beets	9	−1.5	−1.2	−0.1	−0.1	−0.4	−0.7	−0.3	0	2.2	−0.1	−0.1	0	0	0	−0.1	7.4
Asparagus	10	−1.5	−0.8	−0.1	0	−0.2	−0.7	0	0	−0.1	8.1	0	0	0	0	0	29.8
Broccoli (cole crops)	11	−4.3	−1.0	−0.1	−0.8	−0.3	−0.8	0	0	−0.2	−0.1	7.7	0	−0.1	0	−0.1	26.5
Cantaloupes (melons)	12	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	5.4
Lettuce	13	−1.5	−0.4	−0.1	0	0	−0.5	0	0	−0.1	0	0.3	0	2.3	0	0	8.6
Potatoes	14	−1.3	−0.3	0	0	0	0	0	0	0	0	0	0	0	0.3	0	1.2
Tomatoes, processing (and fresh)	15	−2.2	−2.3	−0.1	0	−0.1	−0.6	0	−1.9	−0.2	−0.1	−0.1	0	0	0	1.2	4.3

Table 4. Positive Supply Equations

Commodity	Equation Number	Parameter Estimates: Intercept	Price, Lagged	Output, Lagged	Trend	$\bar{R}^2$	Autocorrelation Coefficient (ρ)	Correlation Between Any Pair of Independent Variables Does Not Exceed	Long-Run Elasticity Estimate
Barley	3	−313,031 (−0.92)	8,336 (2.35)	0.944 (6.59)	—	0.50	−0.42	|0.4|	3.8
Corn for grain	3	−197,896 (−0.69)	12,393 (3.64)	0.553 (1.97)	—	0.91	0.90	|0.8|	5.8
	4	−772,472 (−5.09)	11,373 (4.28)	0.587 (3.85)	24,750 (3.97)	0.91	0.66	|0.9|	5.8
Cotton	3	430,718 (0.66)	6,503 (2.30)	0.120 (0.45)	—	0.38	0.61	|0.1|	0.7
	4	−1,036,430 (−2.95)	10,327 (5.28)	0.289 (1.65)	42,004 (11.16)	0.47	0.38	|0.9|	1.4
Dry beans	3	−68,620 (−2.30)	336 (3.04)	0.984 (13.08)	—	0.76	−0.58	|0.4|	25.2
	4	123,769 (5.02)	235 (2.24)	0.253 (5.21)	−3,534 (−12.44)	0.82	−0.34	|0.9|	0.4
Sugar beets	4	−13,325,700 (−3.59)	1,140,900 (4.07)	0.442 (4.61)	213,757 (12.13)	0.78	−0.34	|0.8|	4.0
Broccoli	4	−107,507 (−3.23)	677 (3.81)	0.596 (10.97)	2,963 (11.71)	0.91	−0.36	|0.9|	3.1
Cantaloupes	3	−186,592 (−3.03)	2,264 (3.92)	0.953 (14.76)	—	0.76	−0.72	|0.2|	12.3
	4	−184,466 (−2.93)	2,252 (3.80)	0.948 (14.40)	56 (4.60)	0.74	−0.71	|0.9|	11.0
Lettuce	4	−212,436 (−1.61)	3,626 (2.94)	0.862 (23.08)	9,432 (10.16)	0.95	−0.41	|0.9|	1.7
Potatoes	3	−350,778 (−1.74)	8,701 (6.04)	0.939 (8.17)	—	0.69	−0.45	|0.4|	4.4
	4	−350,068 (−1.78)	8,654 (5.88)	0.942 (8.43)	−244 (−9.44)	0.67	−0.45	|0.4|	4.6

Note: t-values are in parentheses.

equations.[6] All but two of these long-run supply elasticity estimates are greater than 1.0. Elasticity estimates range from 0.4 to 25.2, with half between 3.0 and 6.0. Where both equations satisfy the stipulated conditions for a commodity, except for dry beans, elasticity estimates from the two equations are similar.

$\bar{R}^2$ values are mixed, exceeding 0.9 for four equations and being less than 0.7 for five. Correlation among independent variables is considerably higher for equation (3) than for equation (2) regressions, generally being in the 0.8 to 0.9 range for equation (3) and 0.1 to 0.4 range for equation (2). Ranging from −0.72 for cantaloupes to 0.90 for corn, the autocorrelation coefficient ρ is positive for four of the equations and negative for ten. Consequently, there is evidence that autocorrelation of errors would be substantial in OLS estimation of each of these equations.

Direct Elasticity Comparison

The LP-derived long-run direct supply elasticity estimates differ substantially from the positive estimates. Simple correlations between both pairs are less than 0.1. However, as many of the LP estimates are lower than the positive estimates as are higher; i.e., for the nine representative crops, six from the linear and three from the quadratic LP-derived equations are lower than the positive estimates (see table 5). The average elasticity is 5.4 for the positive estimates, 2.7 for the linear LP estimates, and 8.3 for the quadratic LP estimates.[7] The average (5.5) of both sets of LP-derived estimates for these nine crops is only slightly higher than the average of the positive estimates.

The similarity of the average magnitudes is particularly striking when it is realized that important variables are omitted from the time-series equations, and the likely effect of at least one important set of omitted variables is to bias the direct elasticity estimate downward. Most agricultural product prices are positively correlated. For example, of the 105 pairwise relations between the fifteen representative commodities in this analysis, deflated 1950–73 annual California prices are positively correlated in eighty-eight cases. In

[6] Long-run elasticities are derived from the partial adjustment model by dividing the short-run elasticity estimates by $1.0 - b_x$.

[7] The mean direct elasticity for these nine crops from the LP with initial data is much higher—42.4 (linear estimate) and 57.1 (quadratic).

Table 5. Comparison of Linear Programming and Positive Estimates of Long-Run Direct Elasticities of State Supply

Representative Commodity	LP-Derived Estimate for Community Group, Expanded Data, Shumway-Chang		Time-Series Estimates for Representative Commodity	
	Linear	Quadratic	Shumway-Chang[a]	Just
Barley	4.8	5.0	3.8	20.0
Corn	1.0	4.0	5.8	5.4
Cotton	0.8	2.1	1.1	0.2
Sugar beets	2.2	7.4	4.0	1.0
Dry beans	4.0	14.1	12.8	—
Broccoli	7.7	26.5	3.1	—
Cantaloupes	1.4	5.4	11.7	—
Lettuce	2.3	8.6	1.7	—
Potatoes	0.3	1.2	4.4	—
Alfalfa	5.4	11.6	—	0.2
Grain sorghum	9.6	17.9	—	4.3
Rice	6.0	8.5	—	0.2
Wheat	4.8[b]	5.0[b]	—	51.1
Mean				
Barley-potatoes (9 crops)	2.7	8.3	5.4	—
Barley-sugar beets and alfalfa-wheat (8 crops)	4.3	7.7	—	10.3
Barley-sugar beets (4 crops)	2.2	4.6	3.7	6.7

[a] Average of equations (2) and (3) when both meet the specified conditions.
[b] Wheat is grouped with barley in the LP analysis. Elasticities of both crops are assumed to be the same here.

addition, the positive correlations are generally of larger magnitude than the negative. Omission of a relevant competitive product price variable from the time-series equation biases the estimated direct elasticity of supply downward.

The effect of omitting policy variables is less clear a priori. In his supply analysis of eight field crops in six California regions, Just accounts for commodity programs, selected alternative crop prices, and risk. Aggregating across regions, we calculated his direct acreage supply elasticity estimates at mean 1960–64 prices. These are listed along with the LP and time-series estimates in table 5. Elasticity estimates based on his equations are on average higher and more varied than either these time-series or LP-derived estimates, suggesting that the direction of bias due to omitted variables may be commodity specific.

The standard deviation of elasticities across crops is higher for the time-series (4.1) than for the linear LP-derived estimates (2.4) but lower than for the quadratic LP-derived estimates (7.8). Since the mean magnitudes and variability across crops for the LP are similar to the time-series estimates and since many of the LP estimates are lower than the time-series estimates, this comparison of direct supply elasticity magnitudes does not support the findings of Quance and Tweeten and Wipf and Bawden that conditionally predictive supply elasticity estimates are generally larger and more variable than time-series estimates. However, the results in terms of individual crops are inconclusive.

Predictive Accuracy

Finding the LP-derived and time-series direct elasticity estimates reasonably comparable only on average but not in individual instances, the following hypothesis was subjected to test: Imposition of the relative magnitude of LP direct and cross-price parameters on a time-series supply model need not significantly reduce its ability to predict future output levels. Since the most recent data used in the estimation of the time-series equations are for 1973, 1974 and 1975 are used as the projection period. Because of rapidly changing economic conditions, testing model predictive accuracy for these years constitutes a very rigorous test.

Predicting with the time-series equations is straightforward. Output for 1974 (1975) is predicted by inserting 1973 (1974) price and output into the relevant equations with parameters previously estimated and solving for 1974 (1975) output. Use of the LP-derived supply equations for prediction is not so clear cut. Assuming profit-maximizing behavior, the LP provides estimates of the long-run desired output levels at alternative prices, and these estimates then become observations for fitting regression equations. Since long-run output levels are never observed in the real world, no observations exist against which to measure the predictive accuracy of the LP-derived output projections. Therefore, one could not simply insert 1973 (1974) prices into the LP-derived supply equations, predict output, and meaningfully compare that prediction with actual 1974 (1975) quantity.

Model for Predicting with LP-Derived Price Parameters

The LP-derived price parameters can be used, however, as prior information for fitting partial adjustment supply models that can be used to predict output. In order to maintain greatest structural consistency with the positive equations, only the linear LP-derived price parameters are considered as prior information.[8] First, a new composite variable is defined from the linear LP-derived price parameters and the time series of crop prices:

$$p'_{it} = \sum_{j=1}^{n} a_{ij} p_{jt}, \tag{5}$$

where p'_{it} is the composite variable for commodity i in year t, a_{ij} is the LP-derived estimate based on expanded data of the jth commodity price parameter in the supply of the ith commodity, and p_{jt} is the deflated price of the jth representative commodity in year t. Partial adjustment supply models are then fit to annual output and composite price data for 1950–73. The models are comparable with the two positive models previously fit to single commodity data:

$$y_{it} = b_{i0} + b_{i1} p'_{i,t-1} + b_{i2} y_{i,t-1} + \mu_{it} \tag{6}$$

[8] We also estimated predictive equations using the quadratic LP-derived price parameters as prior information. These equations satisfy the previously specified conditions for "acceptable" explanatory models for thirteen of the thirty equations (as compared with fourteen for the positive and five for the linear LP models). They predict more accurately than the linear LP equations for half the crops and perform comparably in mean predictive ability.

and

$$(7)\quad y_{it} = b_{i0} + b_{i1}p'_{i,t-1} + b_{i2}y_{i,t-1} + b_{i3}t + \mu_t.$$

After estimating the parameters of these equations, 1974 (1975) output is predicted by inserting 1973 (1974) output and composite price data into each equation. Because they embody the relative price parameters from the LP analysis, they are referred to subsequently as "LP time-series" equations. Estimated parameters are reported in table 6 for the same nine crops as the positive estimates are previously reported. Inclusion of the prior information does not improve the explanatory power of most equations. Fewer own price parameters are significant at the 5% level, and $\bar{R}^2$ values are reduced for as many equations as they are raised (eight of the thirty equations).[9]

[9] An alternative model was also developed for combining the LP results as prior information in a time-series regression. Based on the adaptive expectations premise, a nonlinear search procedure (Talpaz) is used to obtain maximum likelihood estimates of the composite price parameter and each product's price expectation coefficient. Both models are used to develop predictions based on LP-derived price parameters obtained from a stepped linear regression estimation. Because of the nonlinear search, that model is more expensive to solve than the partial adjustment model, and improved predictions result for only four commodities.

At the suggestion of one of the reviewers, the supply equations based on the LP parametrization subsequently are reformulated using simple regression, as reported in this paper. However, because of the expense and lack of predictive improvement from use of the adaptive expectations model in the earlier case, the parameters of that model are not reestimated using the new LP-derived price parameters. That model is developed and the empirical results of the earlier estimation using both models are reported in Shumway and Talpaz.

Table 6. LP Time-Series Supply Equations

Commodity	Equation Number	Parameter Estimates: Intercept	Own Price Lagged ($b_{i1}a_{il}$)	Output, Lagged (b_{i2})	Trend (b_{i3})	$\bar{R}^2$	Auto-Correlation Coefficient (ρ)	Correlation Between Any Pair of Independent Variable Does Not Exceed
Barley	6	−128,997	8,287	0.936	—	0.51	−0.40	|0.4|
		(−0.46)	(2.44)	(6.60)				
Corn for grain	6	267,353	548	0.793	—	0.83	0.32	|0.6|
		(0.93)	(0.76)	(3.01)				
	7	167,513	358	0.432	12,267	0.85	0.53	|0.8|
		(0.85)	(0.63)	(2.71)	(7.26)			
Cotton	6	988,824	−118	0.298	—	0.24	0.30	|0.1|
		(13.27)	(−0.29)	(0.45)				
	7	1,146,800	−14	0.296	−4,525	0.20	0.28	|0.5|
		(1.82)	(−0.02)	(1.36)	(−15.87)			
Dry beans	6	−9,353	210	1.097	—	0.69	−0.50	|0.8|
		(−0.41)	(1.49)	(6.46)				
	7	276,541	406	0.001	−6,550	0.89	0	|0.9|
		(17.22)	(4.46)	(0.01)	(4,361.84)			
Sugar beets	7	3,687,530	95,171	0.144	162,492	0.67	0.14	|0.8|
		(1.88)	(0.92)	(0.93)	(34.16)			
Broccoli	7	10,232	62	0.756	1,288	0.87	−0.41	|0.9|
		(1.47)	(0.35)	(11.52)	(10.41)			
Cantaloupes	6	−186,592	2,264	0.953	—	0.76	−0.72	|0.2|
		(−3.03)	(3.92)	(14.76)				
	7	−184,466	2,252	0.948	56	0.74	−0.71	|0.9|
		(−2.93)	(3.80)	(14.40)	(4.49)			
Lettuce	7	111,909	2,328	0.901	4,002	0.93	−0.28	|0.9|
		(1.72)	(1.22)	(17.00)	(15.80)			
Potatoes	6	1,961,300	2,219	−0.024	—	0.25	0.42	|0.3|
		(3.31)	(1.94)	(−0.06)				
	7	1,520,820	3.147	0.535	−11,067	0.34	−0.20	|0.5|
		(3.54)	(2.85)	(2.92)	(−22.81)			

Note: t-values are in parentheses.

Empirical Comparison of Predictions

The accuracy of the best predictor from each set of equations, i.e., positive equation set and LP time-series set, is compared for individual commodities without regard to whether a priori conditions concerning parameter signs or magnitudes have been satisfied. The percentage of error in the best prediction from each set is recorded for the fifteen commodities in table 7. For 1974 the error ranges across crops from 2.1% to 38.6% for the best LP time-series predictions and from 0.4 to 43.3 for the best positive predictions. For 1975 it ranges from 0.9 to 39.0 for the LP time series and from 0.8 to 57.6 for the positive predictions.

The predictive accuracy of the LP time-series equations is exactly the same as the positive equations for cantaloupes, since the only prior information available from the LP-derived equations is the direct price coefficient. With the LP coefficient providing no restriction nor additional information to the time-series equations, the LP time-series equations are exactly equivalent to the positive equations in that instance.

The best predictor of the LP time-series equations is less accurate than the best of the positive predictors for nine commodities in 1974 and eight commodities in 1975. The LP prediction is considerably better than the positive prediction for two commodities in 1974 and five in 1975 and is much worse for four commodities in 1974 and three in 1975. Mean accuracy of the best LP time-series predictions is a little worse than the mean of the best positive predictions in 1974 but is considerably better in 1975. At the 10% confidence level the mean predictive error of the best conditionally predictive estimate is not significantly greater than the mean error of the best positive estimate in 1974 ($t = 0.2474$) nor significantly lower in 1975 ($t = -0.7382$). Consequently, based on 1974 and 1975 supply predictions, little evidence is found to support the Wipf and Bawden and Quance and Tweeten observations that conditionally predictive estimates tend to be less reliable predictors than the positive estimates of supply. In general, combining LP direct and cross-price supply parameters with time-series data does not substantially reduce the predictive accuracy of the time-series equations. Neither does it substantially improve their predictive accuracy nor their explanatory power.

Conclusions

Linear programming provides a feasible method for estimating both direct and cross

Table 7. Percentage Error in Predicting 1974 and 1975 Output, Best Positive and LP Time-Series Predictive Equations

	Best LP Time-Series Predictor, Expanded Data				Best Positive Predictor			
	1974		1975		1974		1975	
Commodity	Independent Variables[a]	Error (%)	Independent Variables	Error (%)	Independent Variables	Error (%)	Independent Variables	Error (%)
Alfalfa hay	*p, y*	2.1	*p, y*	3.4	*p, y*	1.0	*p, y*	1.8
Barley	*p, y, t*	2.3	*p, y*	18.5	*p, y, t*	1.4	*p, y*	16.3
Corn for grain	*p, y, t*	11.6	*p, y, t*	15.4	*p, y, t*	43.3	*p, y*	39.3
Cotton	*p, y, t*	36.5	*p, y*	0.9	*p, y, t*	21.3	*p, y, t*	6.2
Dry beans	*p, y*	21.7	*p, y*	39.0	*p, y*	1.8	*p, y, t*	1.5
Grain sorghum	*p, y*	38.6	*p, y*	12.5	*p, y*	40.6	*p, y*	15.1
Rice	*p, y, t*	10.8	*p, y*	17.2	*p, y, t*	2.1	*p, y, t*	13.8
Safflower	*p, y*	8.9	*p, y, t*	21.4	*p, y*	9.5	*p, y, t*	14.3
Sugar beets	*p, y*	13.2	*p, y, t*	2.6	*p, y, t*	28.7	*p, y*	57.6
Asparagus	*p, y*	2.6	*p, y, t*	2.9	*p, y*	0.4	*p, y, t*	16.9
Broccoli	*p, y*	13.5	*p, y, t*	1.0	*p, y*	8.3	*p, y, t*	0.8
Cantaloupes	*p, y*	13.3	*p, y*	14.8	*p, y*	13.3	*p, y*	14.8
Lettuce	*p, y, t*	2.8	*p, y, t*	8.1	*p, y, t*	3.0	*p, y*	0.8
Potatoes	*p, y, t*	8.1	*p, y, t*	7.9	*p, y, t*	2.5	*p, y, t*	31.2
Tomatoes	*p, y*	18.1	*p, y, t*	29.2	*p, y*	15.4	*p, y*	19.5
Mean		13.6		13.0		12.8		16.7

[a] Independent variables in best predictive equation: p = lagged price, y = lagged output, and t = time trend.

elasticities of supply. It is presently difficult to use positive models to systematically estimate major cross-price effects. However, linear programming estimates are limited in that they are generated in the context of assumptions and model specifications underlying the linear model. The closer these assumptions and model specifications approach an accurate reflection of the decision environment for agricultural producers, the more valid the results expressing supply relationships are likely to be. Conversely, the less they reflect the decision environment, the less valid their results are expected to be.

This comparison of supply elasticities highlights a high degree of comparability in the average magnitude of direct elasticites but a low degree of comparability for individual crops, between the profit-maximizing LP and the positive time-series estimates for California vegetables and field crops. When the LP-derived parameters are used as prior information in time-series regressions, they do not significantly reduce the accuracy of those equations in predicting 1974 and 1975 supply levels. These findings provide direct contrast to earlier studies that conclude that conditionally predictive supply relationships generally result in larger and more variable estimates of the direct elasticity and less accurate predictions of actual supply levels than positive supply equations. The conditionally predictive estimates in the current study are derived from an LP model designed with profit maximization as the presumed single goal of producers (i.e., without riskiness identified as a variable of concern), with perfect competition imposed as the underlying organizational form of the industry, and with a static perspective without flexibility constraints or other conditions imposed on the adjustment path.

The failure of the prior information to significantly increase either the explanatory power or the predictive accuracy of the time-series regressions is in itself a negative find. Although the inclusion of prior relative estimates of the cross-price parameters in the time-series equations does not hurt, it does not help much either. Apparently, greater realism in the LP's specification of producers' behavioral properties and environment is required to produce real world results that improve substantially on simple econometric models where the latter are also appropriate.

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Availability and Shipment of Grain for Survival of a Nuclear Attack

Carsten M. Haaland

It is assumed that at least 90% of the American population would survive the direct effects (blast, fire, and initial nuclear radiation) of a nuclear attack of 6,600 megatons if about 90 million people were relocated from high-risk areas during a crisis period preceding the attack. If the survivors from the direct effects are protected from radioactive fallout by suitable shelters, the remaining major problem affecting survival will be adequate food. This paper indicates that sufficient grain stocks and transportation will likely be available after the attack to assure survival of the American population.

Key words: grain stocks, linear programming, nuclear attack, survival, transportation.

Imagine a hypothetical situation in which a confrontation between the United States and the Soviet Union results in a massive evacuation of cities in both countries during the crisis period, and this is followed by an all-out nuclear war in which the United States is hit with 6,600 megatons as shown in figure 1.[1] The circles indicate areas of blast overpressure exceeding 2 pounds per square inch above atmospheric pressure, an overpressure that would cause severe damage to most wood-frame buildings (Glasstone). The Soviet Union has the capability of delivering such an attack with its current arsenal of intercontinental ballistic missiles (ICBM's). Furthermore, the Soviet Union has developed an elaborate civil defense to guarantee survival of its people that relies on evacuation as the principal measure of protection (Egorov, Shlyakhov, and Alabin).

Can the U.S. survivors of the nuclear attack continue to survive through the postattack situation? It is assumed that, because of effective relocation from high-risk target areas (such as large cities, industrial and military complexes) to rural areas of about 90 million people during the crisis period and also because of suitable protection from fallout, over 90% of the U.S. population could survive this attack (Haaland, Chester, and Wigner). Suitable protection from fallout requires shelters that not only provide adequate shielding against radiation but also are adequately equipped with food, water, medical supplies, suitable ventilation, radiation survey meters and dosimeters, two-way communications (either radio or telephone), and at least one AM portable radio receiver.

Under these assumptions, one of the most severe postattack problems will be the shortage of food. In most areas there apparently will be less than two to four weeks of reserve processed food (Billheimer, Jones, and Myers), and much of this food will be consumed during the first two weeks after the attack. Most of the food in the form of livestock and poultry will become unavailable, either because much of the stock will be killed by fallout, for which little protection is being provided, or it will be impossible to process the livestock because of the lack of transport facilities and/or processing plants at convenient locations. Many of the surviving food-processing plants will be unable to operate because of power outages or because of intense radiation from fallout.

The outcome of the cumulation of these effects on the food situation in the U.S. is uncertain. Some of the surviving processing plants may be capable of tripling their output of products depending on grains such as flour,

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Carsten M. Haaland is a physicist with the Oak Ridge National Laboratory.

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[1] This attack size and configuration is provided by the Defense Civil Preparedness Agency for planning purposes only.

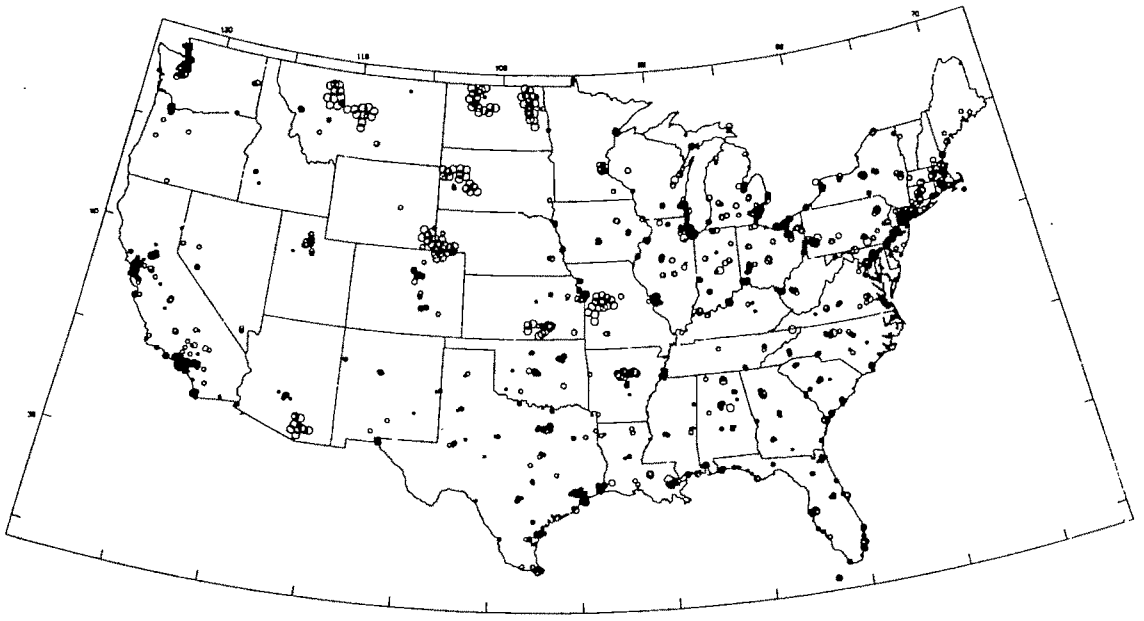


Figure 1. Hypothetical nuclear attack for crisis relocation planning. Circles show areas covered with 2 psi or greater overpressure from blast; number of delivered weapons: 1,444; total yield delivered: 6,559 megatons.

corn meal, corn oil, margarine, and secondary products such as bread, cereals, noodles, and spaghetti. In many areas, the absence of adequate food-processing plants may require that people turn to primitive methods of preparation of raw grains in order to survive. Many old recipes have been rediscovered as a result of the general trend back to nature and self-sufficiency in the United States, and some of these recipes and others have been tested and are described by Kearny.

The innate capability of grain to be stored almost indefinitely with little care and without spoilage, and its suitability as a nearly complete food for human consumption, has drawn the attention of strategic planners throughout the entire known history of man. One of the principal slogans of the late Mao Tse-tung, echoed through Red China and incorporated in its Constitution, is "Dig tunnels deep, store grain everywhere, prepare for war and disaster." The Soviet Union is also preparing to store massive quantities of grain (Kuznetsov) and is currently in the last five-year stage of a "shock construction" project to build storage facilities for 2.5 billion bushels of grain, enough to supply the Soviet population with 300 days of food. It is therefore appropriate that grain should be considered as a survival item for the United States.

Availability of Grain in the United States

The United States has consistently produced more grain annually than required for survival by its population (figure 2). The amount required per day for survival is estimated to be an average of two pounds of grain per person, based on a requirement of an average of 3,000

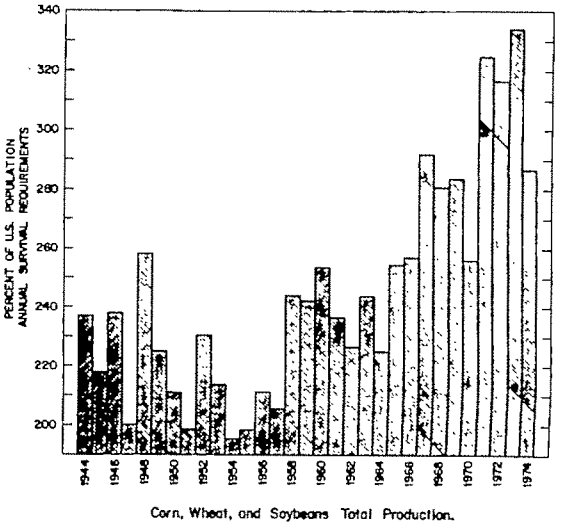


Figure 2. Total production of corn, wheat, and soybeans as a percentage of U.S. population minimum survival requirement

calories per day (Garland). The extra quantity of grain produced is usually primarily for feeding livestock and for export; hence, the amount of grain on hand does not always exceed the annual minimum survival quantity. From figure 3, it is apparent that 30% to 40% of the annual U.S. grain production for each of the years from 1965 through the present would be adequate for the minimum annual survival quantity.

Nearly all the grain stored on farms and 50% to 70% of the grain stored off farms, depending on the season, would not be affected by a nuclear attack. Grain stored off farms is distributed among local town and county elevators, warehouses, processing plants, and large central terminals. Many processing plants and most of the large terminals would be destroyed by the nuclear attack, but the bulk of off-farm storage is in the local elevators in small towns, which would not be affected by the blast and fire of nuclear weapons detonated on major targets. Covered grain is safe for human consumption even if exposed to radiation from fallout in the surrounding environment.

On-farm stocks by themselves have been adequate for at least six months survival supply for the nation during the spring and summer months for all years since 1954. If a nuclear attack occurred during the spring or summer, the stocks on farms would be adequate for survival through September or later. The harvest, although partially destroyed by fallout and possibly damaged by ultraviolet radiation resulting from ozone depletion due to nuclear war (National Academy of Sciences), would provide adequate additional food reserve through the next harvest.

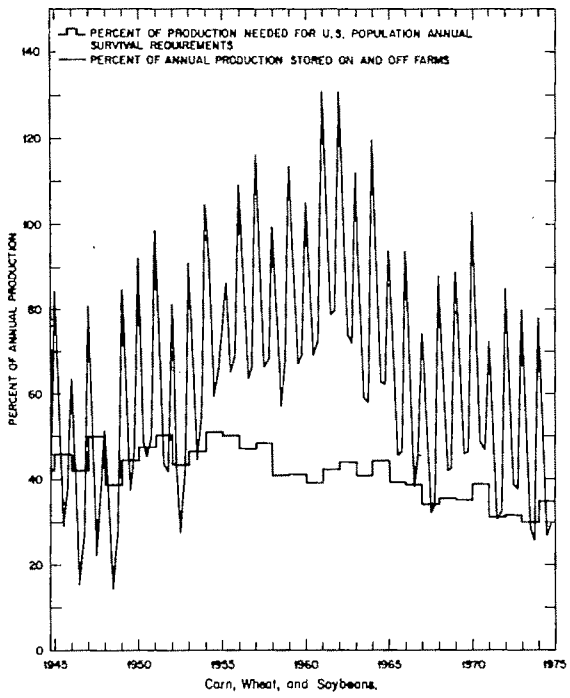


Figure 3. U.S. grain storage relative to survival requirements

Plant responses to irradiation, such as survival, growth inhibition or stimulation, and seed or grain yield, are dependent on dose, dose rate, plant species, type of radiation, and the developmental stage of the plant when irradiated. Killion and Constantin calculate that the fallout gamma dose required to reduce the yield to 50% is 2 to 4 kilorads in wheat and corn and 8 to 12 kilorads in soybeans. Crops are planted at different times at different latitudes. Hence, if the attack occurs on a certain day, virtually simultaneously as far as crops are concerned, crops that have just emerged from the ground at northern latitudes will be more severely affected than those at more southern latitudes that have attained a good stand, or those in the far north that have not yet emerged from the ground.

With these factors under consideration, estimates can be made of the average yield over the entire United States for various fallout conditions for an attack hypothesized to occur in the month of June, at which time the effect of fallout on crops will be most severe (Brown and Pilz). It is assumed, based on data by Killion and Constantin, that when the unit-time reference dose rate R_0 is less than 50 roentgens per hour, the crops are unaffected, when R_0 exceed 1,000 roentgens per hour, the yield is reduced to zero, and when R_0 is in between 50 and 1,000 roentgens per hour, the normal yield is multiplied by the crop yield reduction factor Y, given by $Y = \alpha - \beta R_0^{0.75}$ in which $\alpha = 1.118, \beta = 6.29 \times 10^{-3}$, and Y varies between 0 and 1 for values of $50 \leq R_0 \leq 1{,}000$. This function gives a 50% yield for 2 kilorads exposure, which is conservative according to the Killion and Constantin data.

In order to estimate the crop yield, a specific fallout condition is assumed as shown in figure 4 by contours for five levels of the unit-time reference dose rate on the United States resulting from the hypothetical attack described earlier. The effective wind speed for transport of the fallout particles is assumed to be from the west at 20 miles per hour in this

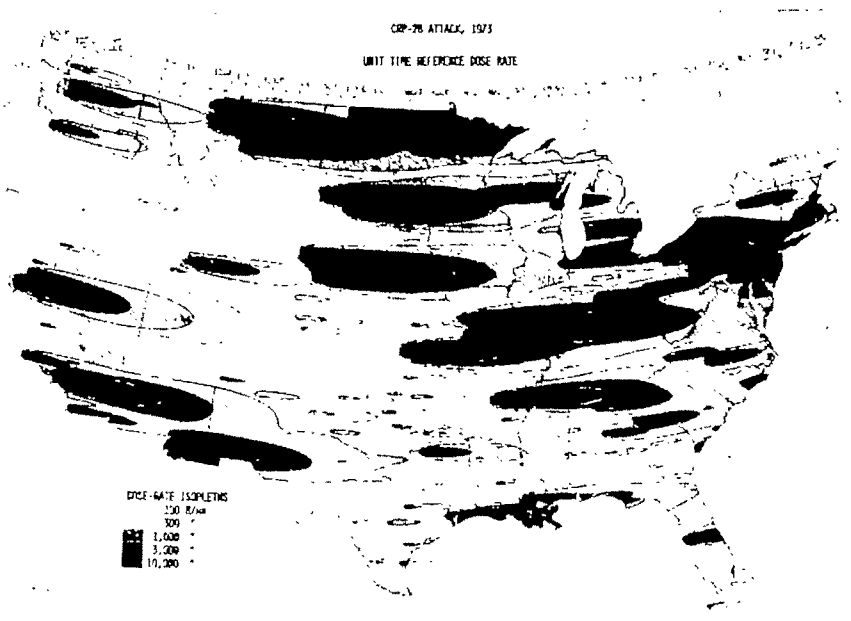


Figure 4. Five contours of possible fallout radiation resulting from a hypothetical nuclear attack

particular case. The crop yield reduction factor Y is applied to the U.S. crop data per county for 1973, as provided to Oak Ridge National Laboratory on computer tape by the Statistical Reporting Service, U.S. Department of Agriculture, and with R_0 given by county from the hypothetical attack. It is estimated that for this particular attack with its special wind conditions, the total crop production will be reduced to approximately 43%, from 6.5×10^{11} pounds to 2.8×10^{11} pounds. The additional loss due to increased ultraviolet radiation from ozone depletion and from reduced temperature due to dust from nuclear war (comparable with the volcanic eruption of Krakatoa) cannot be estimated at present because of inadequate knowledge of the extent of these effects. In comparison with this estimate of 43% survival of total grain yield, calculations by the Federal Preparedness Agency of the General Services Administration indicate a survival of 49% to 50% (private communication), based on a much more sophisticated model developed by Ryan, Garza, and Brown.

For planning purposes, grain stocks on farms and in rural elevators are assumed to be the major source of food required for survival in the postattack period. As seen from the data presented, this source is adequate to supply the relocated population until the following harvest, under most circumstances readily foreseen. It is also assumed that these grain stocks are located primarily in the counties in which they are produced. The location of grain-rich and grain-poor BEA's (business economic areas) in the United States can be qualitatively assessed by the computer-drawn map shown in figure 5, which shows the total quantities of all major grains produced in each BEA of the coterminous United States in 1973, according to USDA figures. A comparison with figure 6, which shows the distribution of relocated people by county according to the ADAGIO program (Schmidt) based on preliminary DCPA (Defense Civil Preparedness Agency) planning, reveals that some regions, such as peninsular Florida, northeastern United States, and parts of California, have a large number of people and are also grain poor. These maps indicate that large quantities of grain may have to be shipped during the first few weeks after the attack in order to avoid massive starvation. It will be more desirable to move grain rather than people, in order to reduce to a minimum the number of people exposed to radiation from fallout. In this situation certain transport workers will be asked to risk exposure to doses of radiation that will not be immediately hazardous but may reduce their average life span and/or increase the incidence of late-life leukemia among them (Haaland, Chester, and Wigner). This situation could be largely avoided if the

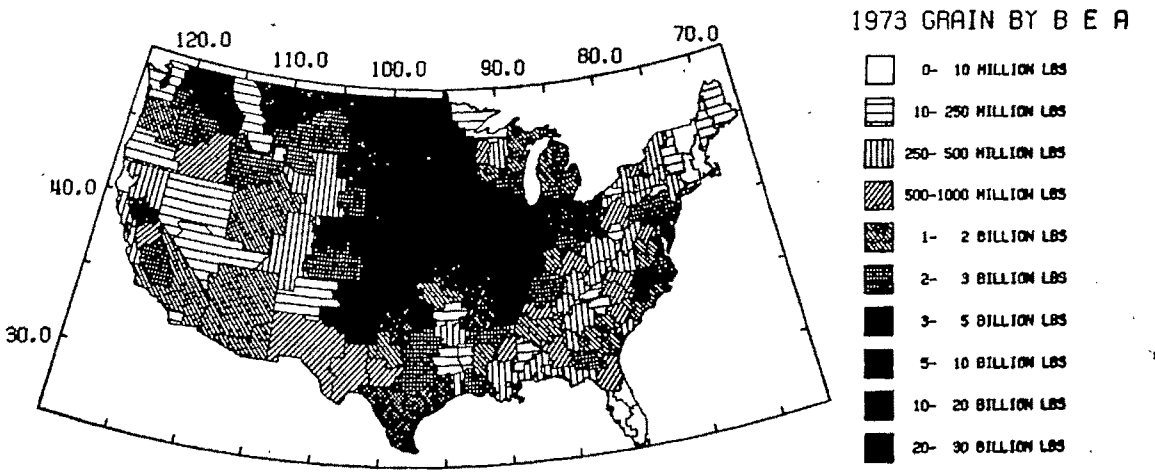


Figure 5. Distribution of production of grain in 1973 by business economic areas. Data source: USDA.

evacuation plans take into account the location of grain stocks in addition to avoidance of high-risk areas, or if the grain is moved and stored before the crisis, as recommended by Garland.

A closer analysis of the actual data shows that 143 counties, containing a total of about 19.8 million people, mostly relocated population, have no grain stocks whatsoever; in other words, the number of food-days available from local grain stocks is zero (figure 7). In other locations, about 26 million people are located in counties in which the local grain stocks can supply some but no more than five days of food; about 8.7 million are in counties with five to ten days food from grain stocks, and so forth as shown in figure 7.

It has been assumed that private grain stocks owned by farmers can be obtained by the government for relief of potential starvation of large fractions of the U.S. population in a postattack situation. Some form of guarantee, possibly federal promissory notes, should be given by the government to assure the farmer of just compensation for his investment and labor and to allay his feelings of anxiety for his own future. Such a guarantee may be difficult to produce in a postattack situation unless it is evident to the farmer that the federal structure of government remains secure

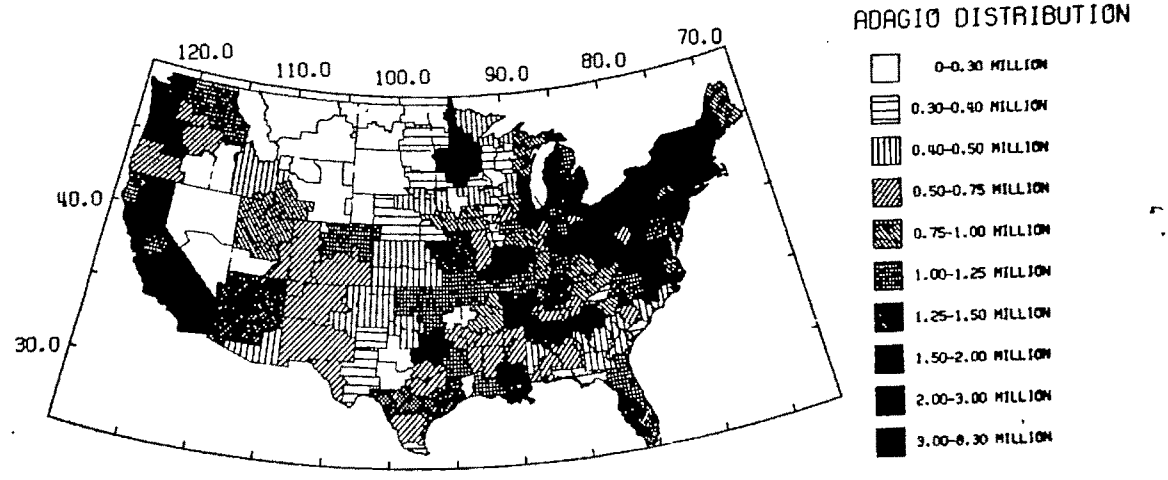


Figure 6. Distribution of people, relocated according to ADAGIO, shown by business economic areas

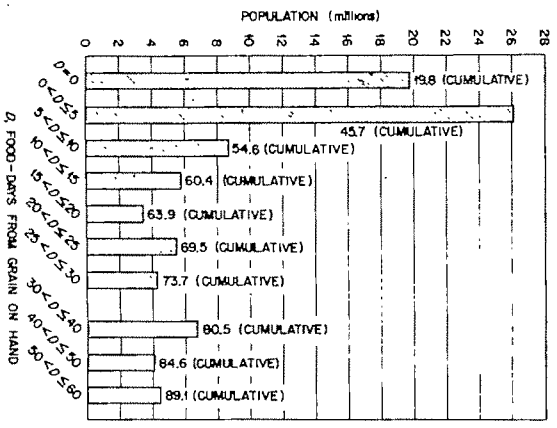


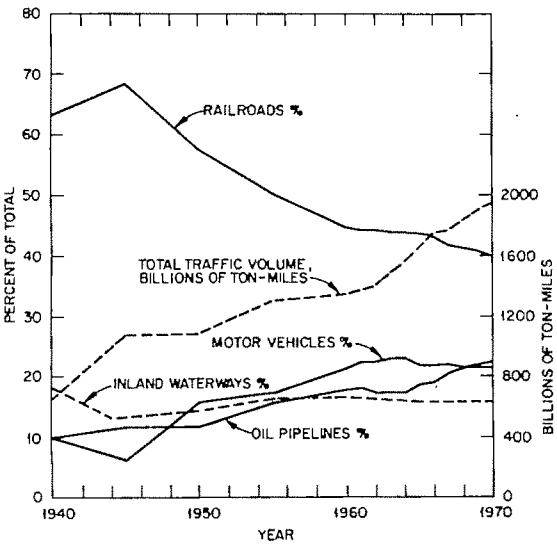
Figure 7. Food-days from grain for various populations

and firmly in power. Federal authority will depend on the existence of a functional national leadership with the appearance of self-confidence and on the existence of a credible recovery program.

Shipment of Grain

The availability of grain in the United States being assured, the next problem to be considered is how to ship the grain. Will enough transportation and fuel survive, and how severely will destroyed bridges, debris, and fallout limit transportation?

The United States has the greatest transport capability of any nation on earth. In 1970, the total volume of intercity traffic amounted to almost two trillion ton-miles (figure 8) of which the railroads transported about 40%, oil pipelines about 22.5%, motor vehicles, 21.3%, inland waterways, 15.7%, and aircraft (not shown in figure 8) about 0.5%.



Volume of Domestic Intercity Traffic (from *Statistical Abstract of the United States 1972*).

Figure 8. Volume of domestic intercity traffic

The estimated number of privately and publicly owned transport units in the United States in 1974 and some previous years is listed in table 1. After a nuclear war, most of the transport capability of motor vehicles and aircraft will probably continue to exist as a result of dispersion and protective measures taken during the crisis period preceding the attack. However, oil pipelines will probably not be able to function at all for some weeks or months after the attack.

Railroad rolling stocks can be moved out of high-risk areas during the crisis period. Most of the major switchyards, warehouses, and repair facilities are located in major cities and would be either severely damaged or destroyed by the hypothetical attack. A previous study (Hamberg, p. 60) indicates that "in no case would rail traffic be completely blocked" by destruction of "rail activity centers," although circuitous routing would be required to get around the damaged facilities in many cases. The major restriction to rail shipments in the early postattack situation will be the destroyed bridges across major rivers such as the Mississippi, Missouri, Ohio, and Tennessee rivers. A few temporary railroad bridge construction sets may exist for military use, and railroad ferries exist at a few river locations, but these will probably not be adequate. Shipments of crucial supplies across rivers during the first few weeks or months after the attack may have to be accomplished by unloading boxcars at transfer points along the rivers, where the materials are then transported across the rivers by barges or by trucks on portable pontoon bridges.

The railroads are equipped to carry grain in large quantities, and loading and unloading equipment for grain in and out of box-cars exists throughout the grain-producing rural areas (Ladd and Lifferth). The lower cost and greater efficiency of rail movement at about 1.62¢ per ton-mile and 200 ton-miles per gallon of fuel (Hirst), as compared with 8.24¢ per ton-mile and 58 ton-miles per gallon for trucks (1973 prices), makes the railroads appear attractive for the major bulk of emergency shipments in the postattack situation. How-

Table 1. Estimated Number of Privately and Publicly Owned Transport Units[a]

	1950	1960	1970	1974
Motor				
Automobiles	40,339,007	61,682,304	89,279,864	104,857,327
Commercial buses[b]	89,000	75,369	88,823	90,072
School and other buses	134,652	196,760	290,198	356,834
Motor trucks	8,598,962	11,914,249	18,748,421	24,589,078
Rail				
Freight train cars	2,008,761	1,965,486	1,784,181	1,720,573
Passenger train cars	43,585	28,396	11,378	7,080
Locomotives	42,951	31,178	29,122	30,220
Air				
Single engine	57,353	68,036	109,673	129,469
Twin engine	2,827	8,241	18,921	23,925
Three engine	30	8	673	938
Four engine	530	1,437	1,444	1,107
Water				
Barges	13,805	16,777	19,809	25,515
Towboats	4,042	4,203	4,230	4,100
Ships	1,099	957	764	578

Source: Transportation Association of America.
[a] Number of units fails to recognize greater capacity and utilization of new equipment.
[b] Includes municipally owned transit units.

ever, trucks will be essential for many rural pickups and deliveries.

There is a trend for truck terminals to be located along interstate highways outside of urban areas. Because of this trend and because of the mobility of the trucks, it is estimated that 60% to 80% of the current trucking capability would survive the hypothetical attack, providing that adequate measures are taken during the crisis period to provide protection during and after the attack.

In 1972, trucks consumed about 8.1 billion gallons of fuel in transporting 470 billion ton-miles of intercity freight at an average rate of 22.2 million gallons and 1,290 million ton-miles per day. This consumption amounted to about 8% of the total motor fuel (105 billion gallons) consumed for all highway traffic (Transportation Association of America). The average quantity of diesel fuel and distillate fuel oil stored in tanks in 1973 was about 5.67 billion gallons and the average quantity of gasoline was about 7.39 billion gallons (U.S. Dep. Interior). About 60% of these fuels will likely be destroyed in the hypothetical attack, which would leave about 2.27 billion gallons of diesel and distillate fuel oil and 2.96 billion gallons of gasoline surviving, if these numbers for 1973 are representative of the fuels in storage at the time of the attack. If this total of 5.23 billion gallons were to be used only by trucks in the postattack situation at the same average rate as before the attack, i.e., at 22.2 million gallons per day, this supply would last for 236 days, which is probably adequate to carry the nation through the survival stage into the recovery stage.

The problem of calculating the shipments of grain from surplus areas to deficit areas such that the total ton-miles of shipment is minimized is a typical problem of linear programming (Hillier and Lieberman). A detailed transshipment model for grain was developed by Ladd and Lifferth primarily to maximize joint net revenue of grain producers, which does not apply in a postattack situation. The development of a model to select shipment routes to minimize radiation exposure to transport workers is considered to be unnecessary for this program because within two weeks after the attack the radiation levels in nearly all areas of the country would decay to such an extent that train and truck operators could pass through the hottest areas without requiring medical attention. Elements of risk in transportation and in the availability of grain could be introduced into the calculations by various models, possibly by modifications of the risk models described by Hazell and Scandizzo. However, the additional complexities and expanded computer program development that would be required by these inclusions are considered to be beyond the scope of this project.

The particular problem at hand is solved with an unpublished program called TRANS-

PORT, developed by Holcombe and modified by Westley and Coleman. The initial solution was attempted with a data base that used counties as the cellular unit of data. When counties are used as the basic data cell, the requirements for solutions of the problem with the TRANSPORT program exceed the memory capability of our large computers; hence, the county information was consolidated into BEA's (business economic areas) as defined by the U.S. Department of Commerce. There are 171 BEA's in the coterminous United States, compared with about 3,300 county-type divisions.

A BEA is considered to be a source if 60% of the 1973 grain production in that BEA provides more than 365 days of food for the relocated ADAGIO population in that BEA, and shipments from a source are terminated when the reserve is depleted to the level of 365 food-days. Distances are computed along a great circle on the earth's surface connecting the geographical centroids of the BEA's.

The problem is to minimize the total ton-miles required to ship grain from BEA's that have a surplus to those that have a deficit. Let Z be total ton-miles, x_{ij} be tons shipped from BEA i to BEA j, d_{ij} be the distance from BEA i to BEA j, X_i be the initial quantity of grain in BEA i, R_i be the reserve quantity of grain stocks that must remain in BEA i after shipments are completed, and P_i be the number of people in BEA i. Then the problem may be stated as follows:

$$\min Z = \sum_i \sum_j d_{ij} x_{ij}$$

subject to

$$\sum_j x_{ij} < X_i - R_i \geq 0$$

and

$$\sum_j x_{ij} = R_j - X_j \geq 0.$$

For this particular problem, the population is assumed to be relocated according to the ADAGIO program as shown in figure 6. The initial grain stocks in each BEA are assumed to be 60% of the 1973 grain production. The grain on hand in BEA i is designated by G_i in pounds, and S represents the number of days of food reserve to be retained in the BEA's with surplus grain.

The parameter D is introduced to provide a time dependence in the program. D is defined as the number of days supply shipped to deficient BEA's. For simplicity, the shipments are assumed to be accomplished in a negligible time.

The grain reserve for grain-rich BEA's is specified by choosing S to be 365 days and by defining $R_i = 0.001P_iS$, based on a requirement of 0.001 tons of grain per person per day. Shipments are allowed from a BEA as long as $G_i > R_i$. For grain-poor BEA's, the amount of grain shipped to BEA j brings the reserve up to $R_j = 0.001P_jD$.

Two cases are considered. (*a*) Shipments are made for one week reserve at a time ($D = 7$) to each grain-poor BEA, and after each weekly shipment the amounts are added and subtracted to the appropriate BEA's, and a new optimum shipment is found for the subsequent week. (*b*) Shipments are made for multiples of a week reserve ($D = 7, 14, 21, \ldots$), and optimization of the shipments is made for the entire period in each case.

These two procedures result in identical solutions for the first six weeks. For the seventh week through the nineteenth week, the weekly shipments (case *a*) result in slightly greater values of cumulative ton-miles than case *b* (2.913 trillion ton-miles compared with 2.825 at nineteen weeks).

A solution of the grain shipment problem for the first six weeks is shown in table 2. The total shipments amount to about 91,000 tons the first week and increase to about 305,000 tons by the sixth week. As might be expected from an explanation of figures 5 and 6, the shipments specified by the solution to the linear program for the first week involve those BEA's that are people-rich but grain-poor, particularly parts of California, Florida, and New England states. The number of train carloads or truckloads or barges that are required to ship the grain if only one mode of transportation is used is also shown for each week in table 2. The number of train carloads (or truckloads) increases from 1,663 (or 5,078) in the first week to 5,785 (or 17,672) in the sixth week.

In comparison, the number of railroad carloads and truckloads per week in 1970, considering only those vehicles suitable for hauling grain, averaged about 266,000 and 308,000, respectively. The sixth-week grain shipments in table 2 require about 2% of the 1970 railroad capability or about 6% of the 1970 trucking capability if only one mode of transportation is used. Actually all three modes of transportation would be used to some extent, although the use of barges would probably be highly limited during the first few weeks because of the destruction to locks and port facilities and

Table 2. Postattack Grain Shipments to Deficit Food Areas

BEA Source		BEA Destination		Distance (Miles)	First Week				Second Week				Third Week			
No.	Name	No.	Name		Tons	RR[a] CL	TRK[a]	Barges	Tons	RR CL	TRK	Barges	Tons	RR CL	TRK	Barges
38	Tallahassee, Fla.	37	Tampa-St. Petersburg, Fla.	261	3,423	63	191	3	Source Exhausted				Source Exhausted			
168	Sacramento, Calif.	170	Eureka, Calif.	168	7,366	134	410	[b]	7,679	140	427	[b]	7,679	140	427	[b]
163	Tucson, Ariz.	164	San Diego, Calif.	328	5,922	108	329	[b]	9,330	170	518	[b]	9,330	170	518	[b]
17	Baltimore, Md.	4	Boston, Mass.	416	13,983				13,984				13,983			
		5	Hartford, Conn.	335	11,146				11,214				11,215			
		3	Burlington, Vt.	459	13,533				14,355				14,355			
		2	Portland, Me.	552	3,854	773	2,362	39	15,757				15,758			
		1	Bangor, Me.	659	0				5,117				6,130			
		14	New York, N.Y.	249	0				29,353	1,633	4,988	82	57,903			
		6	Albany-Schenectady-Troy, N.Y.	377	0				0				3,966	2,242	6,851	112
		12	Binghamton, N.Y.-Pa.	261	0				0				0			
		7	Syracuse, N.Y.	364	0				0				0			
41	Albany, Ga.	37	Tampa-St. Petersburg, Fla.	290	15,180				18,603				18,603			
		36	Miami, Fla.	376	9,968				9,968				9,968			
		35	Orlando, Fla.	231	6,984	585	1,786	30	7,606	658	2,010	33	7,606	658	2,010	33
156	Yakima, Wash.	155	Seattle-Everett, Wash.	218					6,278	115	349	6	12,500	228	695	12
128	Waco, Tex.	130	Tyler, Tex.	134									7,734	141	430	[b]
64	Columbus, Ohio	65	Clarksburg, W.Va.	124									3,261	60	182	[b]
		9	Buffalo, N.Y.	257												
		52	Huntington-Ashland, W.Va., Ky., Ohio	113												
147	Pueblo, Colo.	146	Albuquerque, N.Mex.	205												
88	Eau Claire, Wis.	87	Duluth-Superior, Minn.-Wis.	142												
42	Macon, Ga.	44	Atlanta, Ga.	95												
	Total				91,359	1,663	5,078	72	149,244	2,716	8,292	121	199,991	3,639	11,113	157

Table 2, cont.

BEA Source		BEA Destination		Distance (Miles)	Fourth Week				Fifth Week				Sixth Week			
No.	Name	No.	Name		Tons	RR CL	TRK	Barges	Tons	RR CL	TRK	Barges	Tons	RR CL	TRK	Barges
38	Tallahassee, Fla.	37	Tampa-St. Petersburg, Fla.	261	Source Exhausted				Source Exhausted					Source Exhausted		
168	Sacramento, Calif.	170	Eureka, Calif.	168	7,679	140	427	[b]	7,679	140	427	[b]	7,679	140	427	[b]
163	Tucson, Ariz.	164	San Diego, Calif.	328	9,330	170	518	[b]	9,330	170	518	[b]	9,330	170	518	[b]
17	Baltimore, Md.	4	Boston, Mass.	416	1,394				1,394				1,394			
		5	Hartford, Conn.	335	11,214				11,214				11,214			
		3	Burlington, Vt.	459	14,355				14,355				14,355			
		2	Portland, Me.	552	15,757				15,757				15,757			
		1	Bangor, Me.	659	6,130				6,130				6,130			
		14	New York, N.Y.	249	57,903				57,903				57,903			
		6	Albany-Schenectady-Troy, N.Y.	377	17,752	2,493	7,616	125	17,752				17,752			
		12	Binghamton, N.Y.-Pa.	261	0				22,342	2,899	8,858	145	23,082			
		7	Syracuse, N.Y.	364	0				0				22,190	3,316	10,132	166
41	Albany, Ga.	37	Tampa-St. Petersburg, Fla.	290	18,603				18,603				18,603			
		36	Miami, Fla.	376	9,968				9,968				9,968			
		35	Orlando, Fla.	231	7,606	658	2,010	33	7,606	658	2,010	33	7,606	658	2,010	33
156	Yakima, Wash.	155	Seattle-Everett, Wash.	218	12,500	228	695	12	12,500	228	695	12	12,500	228	695	12
128	Waco, Tex.	130	Tyler, Tex.	134	8,683	158	483	[b]	8,683	158	483	[b]	8,683	158	483	[b]
64	Columbus, Ohio	65	Clarksburg, W.Va.	124	3,830	70	213	[b]	3,830				3,830			
		9	Buffalo, N.Y.	257	0				12,246	293	894	12	27,544			25
		52	Huntington-Ashland, W.Va., Ky., Ohio	113	0				0				9,217	738	2,255	
147	Pueblo, Colo.	146	Albuquerque, N.Mex.	205	2,221	41	124	[b]	4,009	73	223	[b]	4,009	73	223	[b]
88	Eau Claire, Wis.	87	Duluth-Superior, Minn.-Wis.	142					2,903	53	162	[b]	3,003	55	167	3
42	Macon, Ga.	44	Atlanta, Ga.	95									13,709	249	762	[b]
	Total				204,925	3,958	12,086	170	244,204	4,672	14,270	202	304,858	5,785	17,672	239

[a] It is assumed that a closed or covered railroad car (adapted for emergency use) averages 55 tons per load and a closed truck averages 18 tons per load.
[b] No waterways connecting source and destination.

obstructions by fallen bridges. Barges are extremely useful in hauling bulk cargo such as grain, averaging about 1,100 tons per load, equivalent to about twenty average railroad carloads.

The heaviest shipments are from the Baltimore BEA, no. 17, to the New England BEA's, in which 26.44 million people are located according to the ADAGIO distribution. In the seventh week (not shown in table 2), the grain reserve in the Baltimore BEA is exhausted. Shipments to the New England BEA's must come from other more distant BEA's, such as Norfolk, Virginia.

The solution for the shipment problem beyond six weeks may be meaningless for two reasons. First, people may begin to move out of the relocation areas. Second, the Mississippi River may become open to barge traffic, unloading facilities for ships and barges along the Atlantic Coast may begin to operate, and grain shipments from the grain belt may become feasible. A complete solution of the grain shipment problem, involving costs of each mode of transportation and actual distances of travel, is infeasible because the precise location and degree of damage to facilities and the limitations imposed by fallout, debris, and damaged bridges are unpredictable.

The solution of the grain shipment problem indicates that, within the assumptions described earlier, grain can be shipped to alleviate food shortages well within the capabilities of the surviving transportation facilities and petroleum after a large nuclear attack. Limitations and restrictions imposed by radiological hazards from fallout and disruption of communications and electrical power are discussed in greater detail in a report by Haaland, Chester, and Wigner.

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Notes

Intersector-Distributional Implications of Agricultural Technical Progress in an Open Economy: An Extension

Dũng Nguyen

In a recent paper, Akino and Hayami (A–H) present a method to estimate the social benefits due to rice breeding research in the recent experience of Japan's economy.[1] In addition to the estimation of the social rate of returns to public investment in rice research, the authors quantify the distribution of social benefits between consumers and producers based on conventional concepts of consumer's surplus and producer's surplus. In a static demand-supply framework, the authors specify the autarky and the open economy as two polar cases within which reality lies. In another paper with Herdt, Hayami formulates a similar model to account for the distributional impact of technological change in subsistence agriculture, where the Philippines is used as an example. In a sense, the Hayami and Herdt (H-H) model is both an extension and a reduction of the A-H model. For present purposes, the following comparisons between the two papers are particularly relevant.

(*a*) In the H-H paper, three types of income distribution are discussed: intersectoral distribution (producers versus consumers), distribution among producers (small versus large farmers), and distribution among consumers (low- versus high-income class). On the other hand, only the first is examined in the A-H paper.

(*b*) The effect of the government's price control policy is not considered in the H-H model, whereas it is seen as one of two polar cases in the context of the open economy in the A-H model.

(*c*) However, the A-H analysis is extended in the H-H paper by taking into consideration the effect of the ratio of marketable surplus to total output (which may be conveniently termed as the agricultural commercialization rate) on the intersectoral distribution of economic gains.

With respect to (*a*), the present note is concerned only with the first type of income distribution. The extension made by Hayami and Herdt mentioned in (*c*) seems to be quite relevant in today's developing economies, where agriculture may be the more important sector. Furthermore, it may well be speculated that the impact of commercialization rate should be taken into account in analyzing the distribution of gains from rice breeding research in Japan during the period covered by the A-H study (1915–61).

With regard to (*b*), it seems that, by merely identifying the two polar cases, the A-H model would not give specific values for consumer's and producer's gains as the result of a rightward shift in the supply schedule due to rice breeding techniques.[2] Similarly, complete disregard of the price control policy's constraint in the H-H paper would lead to unwarranted interpretations pertaining to intersectoral distribution.

This note is mainly concerned with the issues mentioned in the preceding paragraph. I attempt to extend the above two models to take into account the case of open economy, where it is assumed that the market price is subject to a controlled ceiling price at which the government has to import a certain amount of agricultural produce in order to meet domestic demand.

To conserve space, the reader is referred to the H-H paper for notations and definitions.

The Extended Model

Let us introduce a new variable into the H-H model, namely, ceiling price, which is shown in the graph as $O\bar{P}$. The H-H analysis would not be affected if $O\bar{P} > OP_0$, i.e., if the equilibrium price before technological change is lower than the ceiling price. However, this is clearly not an interesting case in my framework. Thus, the two general cases considered are $OP_0 \geq O\bar{P} \geq OP_1$ and $0 < O\bar{P} \leq OP_1$. For convenience, they are referred to as the first and second general case, respectively, throughout this note.

The First General Case

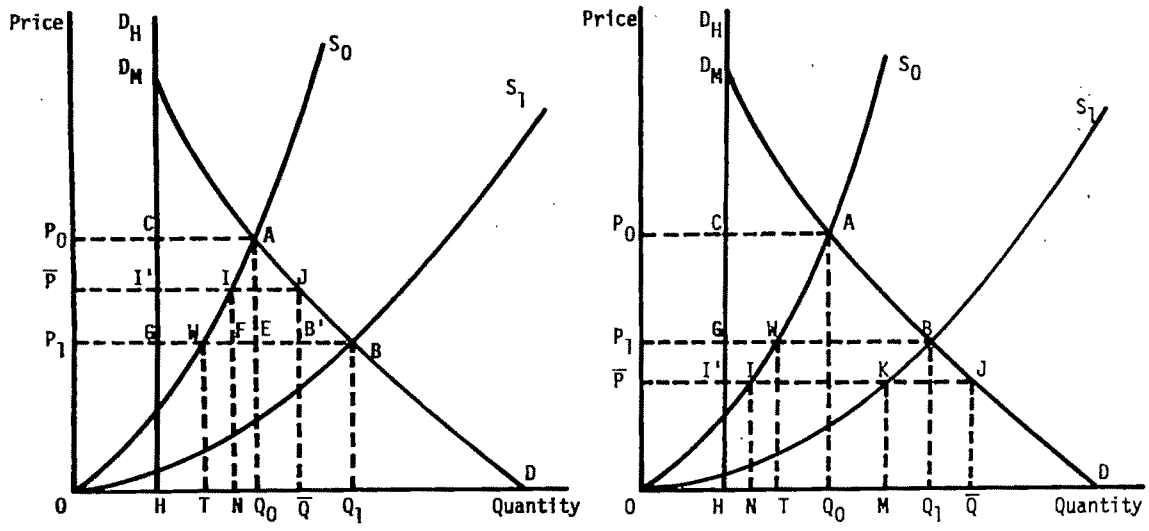
The first general case may be depicted in figure 1.A. With the ceiling price $O\bar{P}$, the quantity demanded is shown as $O\bar{Q} = \bar{P}J$, and the domestic quantity

Dũng Nguyen is a doctoral candidate at the University of Maryland.

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[1] A slightly different version of their paper appears as chapter 6 in Hayami.

[2] In other words, the A-H analysis can only estimate a range of values. Any conclusion drawn from it concerning the distributional impact seems to be uncertain. More importantly, it is shown below that the reality may not even lie within the two polar cases as stated by Akino and Hayami.



A. The First General Case

B. The Second General Case

Figure 1. The impact of technological change

supplied is indicated by $ON = \bar{P}I$. Under normal circumstances, price tends to move upward to the equilibrium point at A. However, with the policy of price control, the quantity demanded is satisfied by import of the crop in question. Quantity imported can be represented by IJ in figure 1.A. Then, due to technological change, a new equilibrium position is established at B with OP_1 and OQ_1 as the new equilibrium price and quantity, respectively. We have change in consumer's surplus: area $JI'GB$, change in producer's revenue: area $BFNQ_1$ − area $H'GF$, and change in cost of production: area BOQ_1 − area ION. Obviously, the effects of the rate r on the change in consumer's surplus and producer's revenue are generally the same between the H-H model and the first general case. Nevertheless, it is equally obvious that the levels of change in consumer's surplus and producer's revenue are generally different.

From figure 1.A, if $O\bar{P} = OP_0$, my first general case becomes the H-H model. At another extreme, if $O\bar{P} = OP_1$, area $JI'GB$ becomes line GB, i.e., there is no change in consumer's surplus. The change in producer's revenue can now be indicated by area $BWTQ_1$, which is clearly independent of the agricultural commercialization rate r.

The mathematical version of the preceding discussion can be seen by first approximating the following relationships:

(1) $\bar{p} = p_0\left(1 - \dfrac{m}{b+n}\right)$ and

$$\bar{q} = q_0\left(1 + \frac{nm}{b+n}\right);$$

and

(2) $p_1 = \bar{p} - p_0\left(\dfrac{k-m}{b+n}\right)$ and

$$q_1 = \bar{q} + q_0\frac{n(k-m)}{b+n},$$

where m denotes the percentage shift in supply due to import such that demand for the crop is satisfied, and variables with bars indicate the controlled market price and quantity. The following approximations are obtained:

(3) Change in consumer's surplus

$$= \bar{p}\bar{q}\,\frac{(k-m)r}{b+n-m},$$

(4) Change in producer's revenue

$$= \bar{p}\bar{q}\left[\frac{(k-m)(n-r)}{b+n-m} + \frac{m}{1+m}\right],$$

(5) Change in cost of production

$$= \bar{p}\bar{q}\,\frac{b[m(b+n)+(k-m)(n-1)]}{(1+b)(b+n-m)(1+m)},$$

and

(6) Change in producer's surplus

$$= \bar{p}\bar{q}\,[(k-m)[(1+m)(1+b)(n-r) - b(n-1)] + m(b+n-m)]\,[(1+b)(b+n-m)(1+m)]^{-1}.$$

Equations (3) to (6) indicate the effects of the commercialization rate on producer's and consumer's gains. Generally, its effects are in the same direction with those discussed in the H-H paper, although the levels of effect are clearly different.

Only when $m = 0$ do equations (3) to (6) give identical results with those from the H-H model. Moreover, if it is assumed that $r = 1$, then the H-H model (or the first general case with $m = 0$) essentially reduces to the A-H autarky situation. In other words,[3]

(7) Change in consumer's surplus $= \bar{p}\bar{q}\,\frac{k}{b+n}$,

(8) Change in producer's surplus

$$= \bar{p}\bar{q}\,\frac{k(n-1)}{(1+b)(b+n)},$$

(9) Change in total social benefit $= \bar{p}\bar{q}\,\frac{k}{1+b}$.

When $k = m$, the first general case describes another extreme situation that would imply self-sufficiency in subsistence crop under consideration. Equations (3) to (6) now become

(10) Change in consumer's surplus $= 0$,

(11) Change in producer's revenue

$$= \bar{p}\bar{q}\frac{m}{1+m} = \bar{p}\bar{q}\,\frac{k}{1+k},$$

(12) Change in cost of production

$$= \bar{p}\bar{q}\frac{mb(b+n)}{(1+b)(b+n-m)(1+m)}$$

$$= \bar{p}\bar{q}\frac{kb(b+n)}{(1+b)(b+n-m)(1+m)},$$

and

(13) Change in producer's surplus

$$= \bar{p}\bar{q}\frac{m}{(1+b)(1+m)} = \bar{p}\bar{q}\,\frac{k}{(1+b)(1+k)}.$$

Thus, the picture is changed. While producers enjoy an increase in income, there seems to be no change at all in the consumer's gain due to technical progress. Another point worth noting is that the commercialization rate r is no longer present in the above equations, i.e., changes in producer's and consumer's gains are clearly independent of the rate r. This case, of course, invalidates some of Hayami and Herdt's conclusions regarding the effects of the rate r. Besides, this situation describes another polar case discussed in the A-H paper, namely, the open economy case.

The Second General Case

Figure 1.B illustrates the second general case where the equilibrium price after technological change is higher than or equal to the ceiling price. Since technological change does not affect the market price, which is the controlled price, there is no change in consumer's surplus. Change in producer's revenue, however, is positive and independent of the commercialization rate as this change can be represented by area *KINM* in figure 1.B. Finally, corresponding change in cost of production is indicated as area *KOM* − area *ION*.

The following equations approximate relevant areas shown in figure 1.B:[4]

(14) Change in consumer's surplus $= 0$,

(15) Change in producer's revenue $= \bar{p}\bar{q}\frac{k}{1+m}$,

(16) Change in cost of production

$$= \bar{p}\bar{q}\frac{kb(b+n)}{(1+b)(b+n-m)(1+m)},$$

and

(17) Change in producer's surplus

$$= \bar{p}\bar{q}\frac{k}{(1+b)(1+m)}.$$

Here is another interesting case that is usually observed in some developing countries where technological progress, although remarkable, cannot increase production level up to the point where total import of a particular subsistence crop is completely substituted. This appears to be the case of the Japanese economy as described by Akino and Hayami: "In reality, in spite of the efforts to shift the rice production function upwards, domestic supply could not keep up with the expansion in demand, resulting in rice imports in the order of 5% to 20% of domestic production" (p. 4).[5]

Thus, this discussion seems to indicate that the reality of the Japanese agricultural situation may be represented by the second general case. On the contrary, the Akino and Hayami autarky and open economy cases are two extremes of the first general case. It should be obvious, therefore, that the reality may not even lie within the polar cases as asserted by Akino and Hayami. The difference between the first and the second general case can be clearly seen. Only when $OP_1 = O\bar{P}$ should the two general cases be identical. In other words, if $k = m$, equations (14) to (17) give consistent results with those in equations (10) to (13).

Table 1 shows the results of the reestimation of the distribution of gains based on formulae of the extended model. Specific formulae used are indi-

[3] These results can be, of course, derived directly from the Hayami and Herdt model. I verify below that these would give very close approximations with those in the Akino and Hayami paper (see table 1). The slightly different notion of rate k in the Akino and Hayami paper may be noted, where k is defined with reference to the quantity supplied after but not before technological change.

[4] I have greatly benefited from the comments of the reviewer who pointed out some errors in a previous formulation.

[5] Unfortunately, they state, "However, this does not require modification of our model" (p. 4).

Table 1. Estimates of Average Annual Benefit in Japan from Rice Breeding Research (Million Yen in 1934–36 Constant Prices)

Period	The Akino-Hayami Autarky Case			Open Economy	"Real" Situation?		
	Producer's Gain[a] (1)	Consumer's Gain[a] (2)	Total[a] (3)	Total Social Benefit = Producer's Gain[a] (4)	Producer's Gain[b] $m = 5\%$ (5)	Producer's Gain[b] $m = 20\%$ (6)	$\bar{p}\bar{q}$[a] (7)
			Before the Assigned Experiment System				
1915–19	−2.86	4.29	1.43	1.43	1.36	1.17	1,906.67
	(−2.86)		(1.43)	(1.43)			
1920–24	−26.75	40.48	13.73	13.49	12.85	11.24	1,904.94
	(−26.99)		(13.49)	(13.38)			
1925–29	−64.55	98.58	34.03	32.86	31.30	27.38	1,961.79
	(−65.72)		(32.86)	(32.31)			
1930–34	−89.86	138.20	48.34	46.07	43.87	38.39	2,002.90
	(−92.13)		(46.07)	(44.83)			
1935–39	−101.74	156.67	54.93	52.22	49.74	43.52	2,153.54
	(−104.45)		(52.22)	(50.75)			
1940–44	−90.56	139.29	48.73	46.43	44.22	38.69	2,004.17
	(−92.86)		(46.43)	(45.17)			
1945–49	−68.02	103.97	35.95	34.66	33.01	28.88	1,989.86
	(−69.31)		(34.66)	(33.95)			
1950–53	−47.94	72.84	24.90	24.28	23.12	20.23	2,037.48
	(−48.56)		(24.28)	(23.94)			
			Under the Assigned Experiment System				
1932–34	−2.03	3.05	1.02	1.02	0.97	0.85	2,033.33
	(−2.03)		(1.02)	(1.02)			
1935–39	−11.56	17.38	5.82	5.79	5.52	4.83	2,172.50
	(−11.59)		(5.79)	(5.77)			
1940–44	−24.92	37.62	12.70	12.54	11.94	10.45	2,006.40
	(−25.08)		(12.54)	(12.45)			
1945–49	−41.90	63.58	21.68	21.19	20.18	17.66	2,002.52
	(−42.39)		(21.19)	(20.93)			
1950–54	−56.64	86.29	29.65	28.76	27.39	23.97	2,030.35
	(−57.53)		(28.76)	(28.28)			
1955–59	−45.27	68.57	26.30	22.86	21.77	19.05	2,612.19
	(−45.71)		(22.86)	(22.62)			
1960–61	−30.65	46.23	15.58	15.41	14.68	12.84	2,801.82
	(−30.82)		(15.41)	(15.31)			

Source: Akino and Hayami.

[a] Figures appearing in parentheses are obtained by using the formulae of the extended model, equations (8) and (9) in text and total social benefit of the open economy case $= \bar{p}\bar{q}\,\frac{k}{(1+b)(1+k)}$. The value of $\bar{p}\bar{q}$ is derived by taking the consumer's gain computed in the Akino and Hayami paper as "given" through equation (7). Furthermore, the values of total social benefit computed from the extended model for the autarky case (column (3) in parentheses) are equal to those computed in the Akino and Hayami open economy case (column (4) not in parentheses). This is by no means a coincidence. The reason is that Akino and Hayami approximate change in total social benefit in open economy case by the formula (their notation) $kp_0q_0 = p_0q_0h/(1+\gamma)$, or, in my notation, $\bar{p}\bar{q}k/(1+b)$, which is exactly change in total social benefit according to the extended model's version of the autarky case (see equation (9)).

[b] By using the formula: change in total social benefit = change in producer's surplus $= \bar{p}\bar{q}k/(1+b)(1+m)$.

cated in the notes below the table. Two alternative values of m are used, 5% and 20%, representing the possible range of import rates as suggested by Akino and Hayami. Given the specific value of m, the generalized formulae would give approximations for the "real" levels of producer's gains, based on which certain conclusions about income distribution can then be made.

In summary, the Akino and Hayami autarky case, the Akino and Hayami open economy case, as well as the Hayami and Herdt model, are only special cases of the extended model being developed so far. When $m = 0$, the extended model reduces to that of Hayami and Herdt. For $m = 0$ and $r = 1$, the results of the Akino and Hayami autarky case are obtained. Finally, if $k = m$ and $r = 1$, one can then arrive at the results of the Akino and Hayami open economy case.

Concluding Remarks

At the beginning of the paper, I argued that the Akino and Hayami analysis cannot give any specific conclusions regarding the intersectoral distribution of economic gains due to agricultural technological progress. Their analysis can only identify two polar situations, and it suggests that the reality of the Japanese experience lies somewhere in between. My extended model, on the other hand, offers a method to specify the distribution pattern once the ratio of import to total output is known. I also demonstrate that the reality of the Japanese agricultural situation may not even lie within the two polar cases as Akino and Hayami assert.

Besides, it seems that effects of the agricultural commercialization rate must also be taken into consideration in the manner suggested by Hayami and Herdt if a closer estimation of the distribution of economic gains is to be expected.

With respect to the Hayami and Herdt model, the conclusion of their paper states that "modern technology, such as the high-yielding rice varieties, benefits both consumers and producers. Within agriculture, it has an effect of promoting a more equal income distribution through downward pressure on prices. . . ."

However, it is shown in my extended model that this conclusion may not be generally valid. For a country that has to import a certain subsistence crop, the rightward shift of the supply schedule due to technological change tends to substitute the import partially or fully; thus, the price level may not be reduced at all. Under these circumstances, as indicated in this analysis, only producers are better off, while consumers are neither better nor worse off. Meanwhile, the agricultural commercialization rate may not have any effect as shown by the absence of the variable r in the respective equations.

On the other hand, if the value of k exceeds that of m, then the conclusions reached by Hayami and Herdt concerning the effects of the rate r are found to be consistent with those from the extended model. However, the level of impact of technological change (variable k) and of the commercialization rate r in the Hayami and Herdt model is different from that in the extended model.

This difference can be clearly seen by comparing Hayami and Herdt's calculation with the values obtained from generalized formulae where various levels of m are assumed (0, 5%, 10%, and 15%). This is done in table 2, where the Philippines is used as an empirical illustration with $k = 10\%$, $r = 0.40$, $n = 0.30$, and $b = 0.30$.

Table 2. Distribution of Gains in Economic Welfare Due to Technical Progress in Rice Production Between Producers and Consumers in the Philippines, 1967/70–1971/72 Averages

	Welfare Gains in Money Terms (Million Pesos)[a]			
	$m = 0$[b]	$m = 5\%$	$m = 10\%$	$m = 15\%$
Consumers	146 (87%)[c]	73 (45%)	0 (0)	0 (0)
Producers	22 (13%)	90 (55%)	153 (100%)	147 (100%)
Total	168	163	153	147

Source: Hayami and Herdt.

[a] The computation is based on the given information: $k = 10\%$, $r = 0.40$, $n = 0.30$, $b = 0.30$, and $pq = 21.90$ million pesos.

[b] Hayami and Herdt's results.

[c] Welfare gains in percentage terms are expressed in parentheses.

Table 2 shows that the distribution pattern of gains varies tremendously with different values of m. Thus, the above-cited conclusion by Hayami and Herdt, who disregard the variable m in their model, may not be valid. Lastly, since I am concerned only with the question of equity, the paper ignores the social gains in terms of foreign exchange due to technological advances in agriculture.

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Benefit-Cost Analysis of Surfaced Roads in the Eastern Rice Region of India

John Spriggs

In a recent study, Easter, Abel, and Norton attempted to measure the contribution of various inputs to total output in the eastern rice region (ERR) of India.[1] They included both the traditional inputs such as land, labor, and fertilizer as well as nontraditional inputs such as irrigation, technology, environmental factors, and infrastructure. They estimated production functions in log form using district level data and found that the production elasticity on surfaced roads was highly significant and very stable under alternative equation specifications. The present research note uses their estimated production elasticity on surfaced roads (0.208) in estimating a benefit-cost measure of public investment in surfaced roads in the ERR. In this paper, a model is set up to estimate the benefits, then costs are estimated, and, finally, the estimated benefits and costs are joined together in a benefit-cost ratio.

According to the Easter-Abel-Norton (EAN) study: "Surfaced roads appear to be important in explaining productivity differences among districts. . . . The absence of roads in a heavy rainfall area such as the rice region has the effect of raising input prices paid by farmers and lowering output prices received by them due to higher transportation costs." Following this, the benefits of public investment in surfaced roads may be assessed as follows. Consider figure 1, which depicts the basic economic interrelationships between the rural producing and consuming sector, the marketing sector, and the nonrural consuming sector. Figure 1(a) describes the supply (S) and demand (D) curves for the rural or food surplus area. Figure 1(b) describes the excess supply (ES) curve from this area and a demand (DU) curve for the urban or food deficit area. Figure 1(c) describes the supply (SM) and demand (DM) curves for marketing services, where the supply of marketing services are assumed to be perfectly elastic over the observed range of services supplied. This is thought to be reasonable, in the absence of congestion costs, following some earlier research (for example, Ruttan).[2] Using a perfectly competitive model, the last mentioned curve is a vertical subtraction of the ES from the DU curve. Equilibrium prices at the farm level (PF_1) and wholesale level (PR_1) and the equilibrium quantity flowing through the system (Ox_1) are determined by the intersection of the DM and SM curves in figure 1(c). Total quantity supplied by the rural sector is OX_1.

The effect of increasing surfaced roads is to lower both the prices of purchased inputs to the rural producer and the costs of transporting the product to the food deficit area. These effects manifest themselves in downward shifts in the S and SM curves, respectively.

Ideally, direct measures of these shifts are desired to determine a unique solution to the gain in economic surplus, but these are not known. However, we do have an estimate of the effect of increasing surfaced roads on crop output from the EAN study.[3] Using this information, solutions can be obtained that encompass a broad range of possible solutions. Three such solutions are obtained here, coinciding with the following possible situations.

(a) The SM curve shifts, but the S curve does not. This assumes the investment in more surfaced

John Spriggs is a research assistant in the Department of Agricultural and Applied Economics, University of Minnesota.

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[1] The ERR as defined by Easter and Abel contains sixty-nine districts in the states of Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa, Uttar Pradesh, and West Bengal.

[2] One may still argue that the type of marketing services required as a result of more surfaced roads may differ from the type envisaged by Ruttan. For example, storage facilities may become more specialized, and the method of transportation may be more capital intensive. These would tend to imply an upward sloping long-run supply curve for marketing services.

[3] EAN's production elasticity on surfaced roads probably underestimates the true effect of increasing surfaced roads on crop output. Consider their production function: $Q = f(I, SR, Z)$, where Q is crop output, I is conventional inputs, such as fertilizer, SR is length of surfaced roads, and Z is other explanatory variables. The function is estimated assuming I and SR are independent variables, but in fact surfaced roads increase crop output in part via an increase in the use of the I inputs. Hence dI/dSR is not zero and is very likely positive. The true effect of increasing surfaced roads on crop output is given by dQ/dSR, where $dQ/dSR = \frac{\partial Q}{\partial I}\frac{dI}{dSR} + \frac{\partial Q}{\partial SR}$. Using instead the production elasticity or $\partial Q/\partial SR$ results in a bias of $\frac{\partial Q}{\partial I}\frac{dI}{dSR}$. In the relevant regression of the EAN study (table 4, regression 8), $\partial Q/\partial I$ is found to be positive for all inputs except labor. But labor is insignificant with a t-value of 0.523. Thus, $\frac{\partial Q}{\partial I}\frac{dI}{dSR}$ is very likely positive and $\partial Q/\partial SR$ underestimates dQ/dSR. The result is that benefits are underestimated, and any benefit-cost ratios will tend to be more conservative than otherwise.

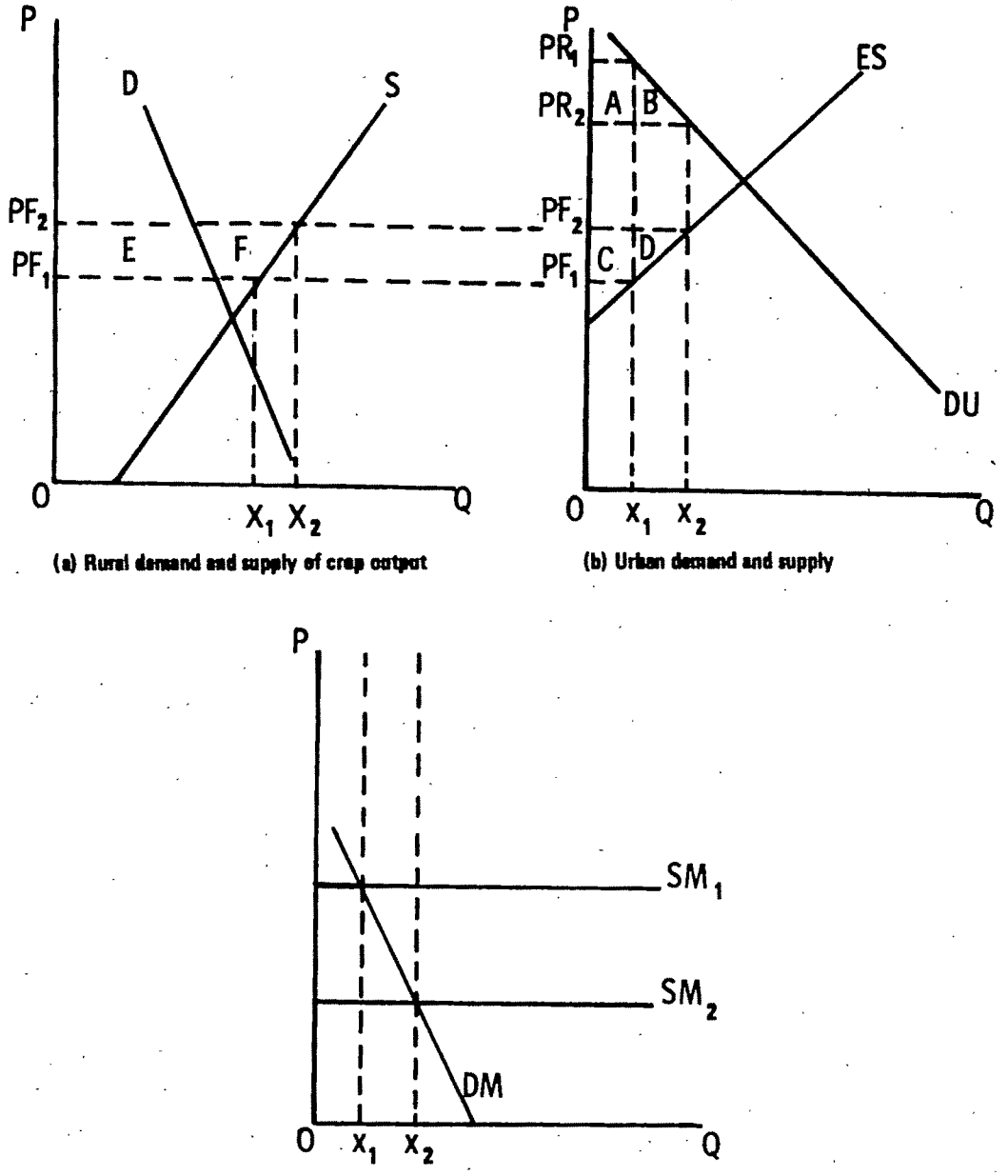


Figure 1. Gain in economic surplus when it is assumed marketing costs are reduced but input prices are constant

roads decreases marketing costs but does not affect input prices. As a result, product price decreases in the urban sector and increases in the rural sector.

(*b*) The *S* curve shifts, but the *SM* curve does not. This assumes that more roads decrease input prices but have no effect on marketing costs. As a result, product price in both the rural and urban sectors will decline.

(*c*) Both the *S* and *SM* curves shift so as to leave farm price unchanged. This assumes that more roads decrease both input prices and marketing costs. As a result, the farm price of output does not change but the urban price decreases.

As shall be seen, these three situations yield, respectively, a high, low, and intermediate estimate of the benefits derived from building more surfaced roads in the ERR.

Consider in some detail the method of solving for the gain in economic surplus under assumption (*a*). A 1% increase in surfaced roads that leads to an

increase in rice output of $(n \times 100)\%$ is postulated. In figure 1, this is represented by the increase from X_1 to X_2. Thus, $n = (X_2 - X_1)/X_1$. While the end result of more roads is greater output, this is assumed to occur only because the increase in roads has reduced the cost of transferring products from the farm to the nonrural consumer. Therefore, the supply of marketing services curve shifts from SM_1 to SM_2. Price paid by the urban consumer falls from PR_1 to PR_2, while the price to producers and rural consumers rises from PF_1 to PF_2. In figure 1(a), rural consumers lose area E in consumer surplus, while producers gain area $E + F$ in producer surplus. Thus, the rural population has a net gain in economic surplus of area F, which is equivalent to area $C + D$ in figure 1(b). Urban consumers gain area $A + B$ in consumer surplus in figure 1(b).

Annual net gain in economic surplus (ANG) = area $(A + B + C + D) = 1/2(x_1 + x_2)[(PR_1 - PR_2) + (PF_2 - PF_1)]$. Using the relation, $n = (X_2 - X_1)/X_1$, and the approximate elasticity relations: elasticity of urban demand = $E(DU) \simeq -[(x_2 - x_1)/x_1]/[(PR_1 - PR_2)/PR_1]$; elasticity of rural supply = $E(S) \simeq [(X_2 - X_1)/X_1]/[(PF_2 - PF_1)/PF_1]$; and elasticity of excess supply = $E(ES) \simeq [(x_2 - x_1)/x_1]/[(PF_2 - PF_1)/PF_1]$; we obtain $(x_1 + x_2) = x_1 + x_1(1 + n[E(ES)/E(S)])$, $(PR_1 - PR_2) = -PR_1 n\, E(ES)/[E(DU)E(S)]$, and $(PF_2 - PF_1) = (nPF_1)/E(S)$. Thus, we obtain ANG $= [x_1 n/2E(S)]\,[(2 + n\, E(ES)/E(S))(PF_1 - PR_1 E(ES)/E(DU)]$.

To determine a value for ANG, values are assigned to x_1, n, $E(S)$, $E(DU)$, $E(ES)$, PR_1, and PF_1 as follows.

(*a*) The initial quantity of rice marketed in the ERR (x_1) was determined as

$$x_1 = \sum_{i=1}^{6} [(\textit{rice output})_i \times (\textit{percentage marketed})_i],$$

where $i = 1, \ldots, 6$ are the states of Andhra Pradesh, Bihar, Madhya Pradesh, Orissa, Uttar Pradesh, and West Bengal.[4] "Rice output" data are for those states or parts of states included in the ERR. "Percentage marketed" data are at the state level only. The values for rice output, percentage marketed, and, hence, x_1 were calculated for the marketing years 1967–68 and 1968–69, and a simple average over the two years was used. Thus, $x_1 =$ 37,230,000 quintals (India, Government of, 1972a, b; 1967–68; 1968–69).

(*b*) For the percentage increase in rice output resulting from a 1% increase in surfaced roads (n) is used the coefficient on surfaced roads obtained in the EAN study, table 4, regression 8. Its value is 0.208.[5]

(*c*) The value of the price elasticity of rice supply ($E(S)$) is an estimate obtained in a study using Punjab data for the period 1914–45 (Krishna). $E(S) =$ 0.59.[6]

(*d*) The value of the price elasticity of demand facing nonrural consumers ($E(DU)$) is an estimate obtained from a recent study using all-India data for the period 1951–68 (Pandey). Thus, $E(DU) = -0.75$.

(*e*) To obtain the value for the initial price facing nonrural consumers (PR_1), the following process was used. For each of the six states in the ERR, data were obtained on the annual average wholesale prices of rice at selected markets in 1968 and 1969. The number of markets varied between states from three to six depending on the availability of data. Those in which prices were fixed by the government were omitted. For each state a simple average price was determined over the relevant markets and over the two years. The six simple average prices were weighted by the quantity of rice marketed in each state (or part of state) to obtain PR_1. Thus, $PR_1 =$ 113 rupees (Rs) per quintal (India, Government of, 1972b).

(*f*) Let the initial price received by producers (PF_1) equal $PR_1 - M_1$, where M_1 is the marketing margin when x_1 is marketed. No data could be found on the size of M_1. It was arbitrarily decided to assume $M_1 = 0.1\, PR_1$ and to use the resulting value of PF_1. As it turns out, the solution was not very sensitive to the size of the marketing margin. For example, when the marketing margin was doubled, the gain in economic surplus declined by only about 5%.[7]

(*g*) The price elasticity of excess supply ($E(ES)$) is given by $E(ES) = E(S)\, X_1/x_1 - E(D)\,(X_1 - x_1)/x_1$, where the values for $E(S)$ and x_1 have already been determined. The value of $E(D)$, the elasticity of rural demand, is assumed to be equal to $E(DU)$ PF_1/PR_1 or 0.68; and X_1, the initial quantity of rice produced in the ERR, is determined as follows. Rice output in the ERR was calculated for each of the marketing years 1967–68 and 1968–69, and a simple average over the two years was used. Thus, $X_1 =$ 207,970,000 quintals (India, Government of, 1972b, 1967–68, 1968–69). The value of $E(ES) =$ 6.4.

Using the values obtained in parts (*a*) through (*g*) above, the annual net gain in economic surplus was found to be Rs 141 million, of which about 91% was distributed in the urban consuming sector.

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[4] The district of Bhandara (Maharashtra) is included with Madhya Pradesh.

[5] The dependent variable in the EAN study is the total crop output of which rice is the major crop. In this note, "the dependent variable" is simply rice output. The implications are as follows. If in fact all crops increase in output by about the same percentage, then the benefits will be underestimated by ignoring those benefits accruing to the nonrice crops. If in fact only rice increases in output, while other crop outputs remain the same or decline, then the benefits will be underestimated because the roads coefficient in the EAN study will be lower than if "rice output" were the dependent variable. The converse holds if other crop outputs increase while rice output does not.

[6] While the elasticity may be suspect since it neither pertains to the same region nor similar time period considered here, the benefits are not overly sensitive to changes in this elasticity. A 10% increase in this elasticity leads to a reduction in ANG of 4% under the first assumption, an increase of 4% under the second assumption, and a negligible change under the third assumption.

[7] Under the second and third assumptions, a 10% reduction in PF_1 will reduce ANG in economic surplus by 4% in each case.

Table 1. Benefits, Costs, and Benefit-Cost Ratios of Increasing Surfaced Roads by 1% in the ERR

	Benefits	Costs		*B/C* Ratio
		Development	Annual	
	———Million Ruppees, 1969 Prices———			
SM curve shifts, *S* curve does not	141	57.8	2.0	10.4
S curve shifts, *SM* curve does not	91	57.8	2.0	6.7
Both *SM* and *S* curves shift	108	57.8	2.0	8.0

Before considering the costs, turn briefly to the estimation of benefits under the two alternative assumptions. The methods of solution are not detailed, as they are of the same geometrical variety that was used above. Under these assumptions in which the *S* curve shifts, the shifts are assumed to be in a parallel fashion. Under the second assumption, where only the *S* curve shifts, annual net gain in economic surplus was found to be Rs 91 million, of which about 88% was distributed in the rural sector. Under the third assumption, where both the *S* and *SM* curves shift in such a way as to leave *PF* unchanged, the annual net gain in economic surplus was found to be Rs 108 million, of which about 60% was distributed to the urban consuming sector.[8]

With regard to the costs of a 1% increase in surfaced roads in the ERR, development cost and maintenance cost are considered. To obtain estimates of these costs, annual data (1959–69) were obtained on an all-India basis for the length of extramunicipal surfaced roads maintained by Public Works Department and Local Bodies and for the development and maintenance costs of state roads (deflated by the wholesale price index for India, all commodities) (India, Government of, 1971).[9]

A value for development cost was obtained by summing the deflated annual development costs over the ten-year period and dividing by the difference in road length between 1959 and 1969. The average development cost determined in this way is Rs 56,700 per kilometer (1969 prices). A value for maintenance cost was obtained by dividing the deflated annual maintenance cost by road length each year, 1959–69, and then averaging the results. The average maintenance cost determined in this way is Rs 1,970 per kilometer-year (1969 prices).

It may be argued that since these costs are drawn from all-India data they may not accurately reflect the cost of constructing or maintaining roads in the ERR because the higher than average rainfall in this region results in road costs above the national average. Moreover, bridge costs are ignored. Therefore, the cost figures arrived at above are doubled, and these adjusted costs are used in the following analysis.

The total length of extra-municipal surfaced roads in the ERR in 1969 (maintained by the Public Works Department) was about 51,000 kilometers. To increase road length by 1% (or 510 kilometers) involves a development cost of Rs 57.8 million (1969) and an annual maintenance cost of Rs 2.0 million (1969) (India, Government of, 1971; West Bengal, Government of).

To obtain a benefit-cost measure, assumptions about the flow of costs and benefits need to be added. Assume that the new roads are constructed within a year and the full benefits and maintenance costs accrue for each of the following ten years. After this time, the roads are scrapped with a zero salvage value. With regard to the rate of discount, since the major part of costs occur at the start, while the benefits are spread out evenly over ten years, the higher the discount rate, the lower is the benefit-cost ratio. By choosing a discount rate on the "high" side, say, 15%, any error will be on the side that tends to lower the ratio of benefits to costs. Allowing a 15% rate of discount, the resulting benefit-cost ratios under the three alternative assumptions are summarized in table 1.[10] The benefits and costs are also included for reference.

The results indicate that benefits relative to costs are substantial and, hence, that a lack of surfaced roads in the eastern rice region of India is likely an important constraint to development there. The Easter, Abel, and Norton study isolates the effect of surfaced roads as a regression coefficient. The present research note attempts to translate their result into a benefit-cost ratio. Although the calculations lack precision because of the sparsity of information, any error will tend to be on the side that will lower the ratio of benefits to costs. Despite this, the results indicate that increasing surfaced road density in the eastern rice region has a high payoff.

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[8] While parallel shifts in the S curve are assumed under both the second and third assumptions, an alternative assumption of proportional shifts has a substantial effect on ANG in economic surplus. Recalculating the gains under this alternative assumption yields the values of Rs 51.6 million and Rs 86.6 million, respectively.

[9] State roads includes extramunicipal surfaced roads maintained by Public Works Department and Local Bodies. However, unsurfaced roads are also included in state roads. Hence, to this extent, the costs obtained in this note are probably biased upward.

[10] In the second and third cases, if the *S* curve is assumed to shift in a proportional rather than a parallel way, the *B/C* ratios are then 3.8 and 6.4, respectively.

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Land Values and Allotment Rents

J. B. Bullock, W. L. Nieuwoudt, and E. C. Pasour, Jr.

The concept of economic rent is frequently used in analyzing the effects of price supports for crops produced under allotment programs. An allotment is an example of a resource that has no alternative use and is perfectly inelastic in supply. Allotments are fully utilized and, hence, acquire economic value as long as the return to the resources required in allotted crops is greater than from alternative enterprises. From an industry standpoint, these annual returns to allotments are economic rents in the classic sense.[1]

In practice, output is often restricted through the use of the land input (e.g., peanut allotments). When the output of a product is restricted through a land or acreage allotment, the annual rent to the allotment is capitalized into the price of land. It is common practice by economists to refer to these "quasi rents" to land (and other factors not perfectly elastic in supply) as economic rent.[2] Economic rent, as used throughout the remainder of this paper, is defined as the difference between the total payment to the resource and the opportunity cost of a resource not perfectly elastic in supply. The resource being discussed is land to which allotments are attached.

Since the value of rents accruing to acreage allotment rights become capitalized into land values (assuming that allotment is the only input perfectly inelastic in supply), the primary beneficiaries of such programs are the landowners at the time the program is implemented. If at a later date the allotment program is eliminated, land values again are altered. In most cases, land values decline *ceteris paribus*. This paper demonstrates, however, that the change in land value (and, hence, wealth) is seldom equal to the capitalized value of the allotment rents.

Most analyses of the effects of government programs on land prices assume that land is of uniform quality or productivity. Such analyses mask the differential effect of price support and allotment programs on land values for land of differing levels of productivity. In reality, allotment values for a given crop are observed to vary widely between production areas within states and between states.[3]

The purpose of this paper is to examine the effects on land values of abolishing an allotment program and to show why the effect is likely to be different for land in different production areas, depending upon the productivity and alternative uses of land in producing the allotted crop. The relationship between the elasticity of supply and land rent for homogeneous land is first investigated. After demonstrating the hypothetical relationship between land rent and allotment rent, the results of a recent empirical study of peanut allotment values are shown to be consistent with the theory developed.

Identification of Land Rent and Allotment Rent

The market for land used in the production of the allotted crop is illustrated in figure 1. The supply (opportunity cost) of land to be used for this crop is represented by SS,[4] while D_1 is the demand for land by producers of this crop if no price support or acreage restriction program is in effect, and Q_e is the amount of land that would be used to produce the crop if no price support or acreage restrictions are in effect. The existence of a product price support above the free market level shifts the demand for land to D_2, since the output from each acre is more valuable while production costs do not change. The acreage allotment imposed as a part of the price-support program is Q_a.

The price-support, acreage-restriction program generates annual payments to land of $\$P_s Q_a$. However, the opportunity cost of this land is only the area F. The marginal opportunity cost of land used by the allotment (Q_a acres of land) is P_o. Thus, landowners receive annual land rents equal to the area E and allotment rents equal to the area $A + B + C$. The capitalized value of $P_s Q_a$ represents the market value of Q_a acres of land and allotment. The allotment alone has a market value equal to the capitalized value of $A + B + C$ on this class of land.

J. B. Bullock is the research manager, Farmbank Research and Information Service, Omaha, Nebraska; W. L. Nieuwoudt is a senior lecturer, University of Natal, South Africa; and E. C. Pasour, Jr., is a professor, North Carolina State University.

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[1] Allotment values are price determined and represent rents in the aggregate. Allotment value is a cost of production and not a rent to the individual firm.

[2] Economic rent is a much used and seemingly simple concept. Yet, as Mishan (1959, 1968, 1969), Shepherd (1970, 1971), Wessel, and others have shown, the concept is ambiguous and confusing even in theory.

[3] These differences may be due to restrictions on the mobility of allotments, as well as variations in land quality. In either case, there are differences in the effect on land values due to changes in the allotment.

[4] All inputs, except land, are assumed to be perfectly elastic in supply for the particular class of land in question. Payment to land is total gross receipts per acre minus payments to all other factors of production.

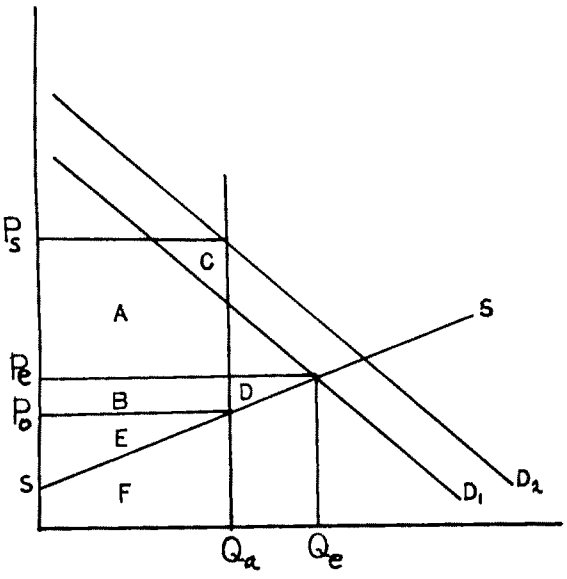


Figure 1. Illustration of allotment and land rents

What happens to the producer's wealth and land values in the situation depicted in figure 1 if the allotment program is abolished? Land used in the production of this crop expands to Q_e. Annual per acre payments to land fall from P_s to P_e (the opportunity cost of Q_e acres of land). Annual allotment rent falls to zero. However, as land used in the production of this crop is increased from Q_a to Q_e, the loss in allotment rent is offset to some extent by increases in land rents (area $B + D$). The annual loss in rent in this case is only the area $A + C - D$. The area B is captured as land rent instead of allotment rent. The wealth loss to allotment holders in the form of reduced land prices is the capitalized value of $A + C - D$, not $A + B + C$, and, hence, is less than the market value of the allotment (the capitalized value of $A + B + C$).

Land Productivity and Rent

Figure 1 illustrates the industry-wide effect on land rents and allotment rents when an allotment is eliminated. The specific effect of a change in allotment value depends on the class of land to which the allotment is attached. The direction and magnitude of the change in land rent for each land class depends on the relationship between P_s (the annual marginal value of Q_a acres of land with the price-support, acreage-restriction program in effect), P_e (the annual marginal value of land if no price-support, acreage-restriction program is in effect), and P_o (the annual marginal opportunity cost of Q_a acres of land). Four possibilities exist.

In case 1, $P_s > P_e = P_o$. This situation is illustrated by figure 2. The area C represents annual land rent, and the area $A + B$ represents the annual

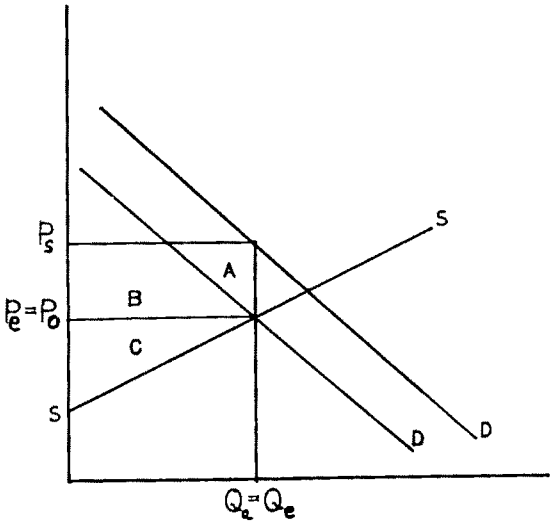


Figure 2. Land rent not affected by allotment removal

allotment rent. The capitalized value of $A + B$ represents the amount by which allotment rights increase the market value of this class of land.

When the allotment is abolished, the annual per acre land payment falls to P_e. In the situation illustrated by figure 2, the amount of land used in the production of this crop does not change since $P_e = P_o$ at Q_a. However, annual rents accruing to landowners who previously had allotments are reduced because allotment rents are eliminated. The per acre value of land decreases by the capitalized value of the annual allotment rent $(A + B)$.[5]

Case 2, $P_s > P_o > P_e$, is illustrated in figure 3.[6] With the existence of the allotment Q_a, annual land rents are represented by the area $D + E + F + G$ and allotment rents by the area $A + B + C$.

The amount of land used to produce this crop is reduced from Q_a to Q_e when the allotment program is abolished, since the opportunity cost of land under the allotment program (P_o) is greater than the marginal land value after allotments are abolished (P_e). The land withdrawn from production of this crop incurs a loss in value equal to the capitalized value of A plus F (i.e., a portion of both the allotment and land rent).

Similarly, there is a decrease in the value of land remaining in the production of the crop equal to the capitalized value of $B + C + D + E$. Thus, in this case, land values decrease by more than the capitalized value of allotment rents $A + B + C$, and land is removed from the production of the crop.

[5] This case also includes the situation where the supply of land is perfectly elastic at P_o. In this case, there are no land rents, and capital losses from abolishing the allotment program are exactly equal to the capitalized value of the stream of allotment rents.

[6] In reality, allotment programs, when instituted, reduce use of all classes of land. Subsequent changes in technology or opportunity costs of competing land uses, however, could result in the situation depicted in figure 3.

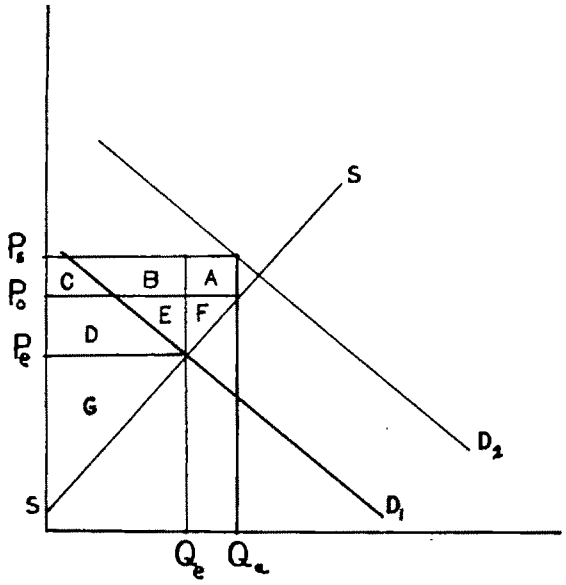


Figure 3. Land rent decreased by allotment removal

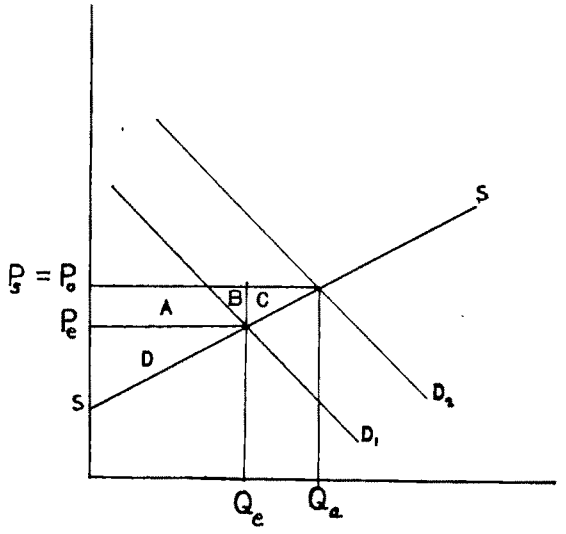


Figure 4. Zero allotment rent

The per acre loss in value of land withdrawn from production when the allotment is abolished is less than the value loss for land that remains in production of this crop. However, in both cases, the decline in land value exceeds the capitalized value of allotment rents.

Case 3, $P_s > P_e > P_o$, is illustrated by figure 1. As shown earlier, the decrease in land values is less than the capitalized value of the allotment. The change in the total value of this class of land when allotments are abolished depends on the relative magnitudes of area $A + C$ and area D. Possibly, D will exceed $A + C$, and total land values could be increased by the removal of allotments.

Case 4, $P_s = P_o > P_e$, is illustrated by figure 4. In this case, there are no allotment rents, since the allotment is not an effective constraint on output. Annual land rents equal $A + B + C + D$.

Production of the allotted crop declines when the allotment program is abolished, since the opportunity cost of land exceeds the marginal value of Q_a acres of land under a competitive product market. The reduction in product price reduces annual land rents and, therefore, land values. The value of land removed from the production of this crop declines by the capitalized value of C. Land remaining in production of this crop is reduced in value by the capitalized value of $A + B$. Average land prices decline, even though the allotment is not an effective constraint on production and has no capital value itself (apart from its effect on land rents).

If no specialized inputs exist and land is perfectly elastic in supply, there are no land rents, and the entire value of the price-support program is reflected in allotment rents. If, on the other hand, land is completely specialized and land supply perfectly inelastic, the entire value of the price-support program is reflected in land rents. Neither of these polar cases are relevant, however, in analyzing the relationship between allotment rents and land rents for most real world allotment and price-support programs. In real world cases where land is partially specialized so that land supply is upward sloping, allotment programs affect land rents.

The elasticity of supply of a particular class of land decreases as the number of alternative uses of this land decreases. The effect (of allotment removal) on market values of land increases as the supply elasticity of land decreases. The more inelastic land supply, the more land rents increase to offset the loss in allotment rents when price supports and allotments are abolished. Stated differently, increases in land rents offset more of the loss in allotment value as the more inelastic is the supply of land.

In reality, allotment values are observed to vary widely from county to county and from state to state. In the case of peanuts and tobacco, land and allotment rents vary within and between states. Higher allotment rents are found in areas that have more specialized inputs in producing the product in question. However, one cannot conclude that producers in areas where allotment rents are highest suffer the largest windfall losses when allotments are abolished. It can be expected that price increases of land and other specialized inputs offset more of the loss in allotment rents in such areas when allotments are abolished.

Empirical Application

Results of a recent analysis of the peanut program are consistent with the above theory.[7] Peanut al-

[7] Several alternatives to the current peanut price-support and

Table 1. Peanut Allotment Rental Values and Portion of Allotment Rents to be Captured as Land Rent, Selected Regions, 1973

State	Allotment Rental Value ($P_s - P_o$)	$P_s - P_e$	$P_e - P_o$
	——— $/Acre ———		
North Carolina	84.40	74.40	10.00
Virginia	100.60	86.53	14.07
Georgia	150.60	78.24	72.36
Alabama	77.90	63.58	14.32
Florida	172.50	83.26	89.24
Texas			
Irrigated	83.20	67.90	15.30
Nonirrigated	13.50	33.22	−19.72
Oklahoma			
Irrigated	142.40	105.47	36.93
Nonirrigated	70.10	51.68	18.42

Source: Nieuwoudt, Bullock, and Mathia 1976a.

lotment rents are found to be higher in Florida and Georgia than in other peanut-producing states. The study revealed that under yields and prices existing in 1973 the abolition of peanut allotments and allotment rents in these states would have been accompanied by significant increases in land rents due to the states' comparative advantage in producing peanuts.

The study of alternative peanut policies estimates peanut allotment rents and the capital losses that would be incurred in eliminating the current allotment program. The estimated annual rent per acre of allotment[8] (shadow price of peanut allotment) is shown in table 1 for the producing areas examined in the study. The rental values shown in the first column of table 1 are estimates of the differences between P_s and P_o for the allotted acreage for each region in 1973.

The support price for peanuts in 1973 is 16.2¢ per pound. The estimated 1973 equilibrium price in a free market setting is 13.0¢ per pound. Thus, the support price exceeds the estimated equilibrium price by 3.2¢. An estimate of $P_s - P_e$ per acre in each region is obtained by multiplying average yield in the region by 3.2¢ per pound (table 1). This is an estimate of the net reduction in rents that would have occurred as a result of abolishing allotments.

The marginal value of peanut land after the allotment program is abolished (P_e) minus P_o is an estimate of the portion of allotment rent that is captured as land rent if the allotment program is abolished. This can be estimated as $P_e - P_o = (P_s - P_o) - (P_s - P_e)$. These estimates are shown in the third column of table 1. The larger the number, the greater the comparative advantage the area has relative to other areas in producing peanuts.

These data are consistent with the hypothesis that case 3 (figure 1) is the predominant characterization of peanut production in all regions, except the nonirrigated lands in Texas. The marginal value of the land used in the production of this crop in the absence of price supports is higher than the supply price at the current allotted level of production. Under these conditions, abolishing allotments increases production (as explained above), and the resulting increase in land rent offsets some of the decrease in allotment rent.

Peanut production in nonirrigated areas of Texas exhibits the characteristics of case 2 (figure 3), where the supply price at the allotted quantity (P_o) exceeds the equilibrium marginal land value in the absence of an allotment program (P_e). Thus, if the peanut allotment program had been abolished in 1973, land would have been withdrawn from peanut production in the dryland farming area of Texas.[9] In addition, the market value of land then in peanut production would have declined. Moreover, the decline in land values would have been greater than the capitalized value of the allotment as illustrated by figure 3.

Peanut production is expected to expand in all other producing regions if the allotment program is abolished. This is generally accompanied by a decline in the market value of land currently associated with the allotment. However, the decline in the market value is less than the capitalized value of annual allotment rent, as illustrated by figure 1 and the numbers in the third column of table 1. Land currently in peanut production decreases in value by an amount equal to the capitalized value of $P_s - P_e$. The value of additional land brought into peanut production increases in value by the capitalized value of $P_e - P_o$. This increase in land value offsets some of the capital losses on allotment land. In the cases of Georgia and Florida, the values of $P_e - P_o$ and $P_s - P_e$ are almost equal. In these states, the decline in the total value of land suitable for peanuts might be quite small, since peanut acreage is predicted to expand by 78% in Georgia and 133% in Florida as a result of allotment removal.[10]

Summary

If land is the only specialized input, as assumed in this note, all rents can be attributed to land and

acreage-allotment program were considered. A linear programming model was used to compare the effects of the three alternative policies on geographic location of peanut production, producer and consumer surplus, treasury costs, and value of allotments (Nieuwoudt, Bullock, and Mathia 1976b).

[8] Calculated using average yield for the region.

[9] The programming model of the study indicates that peanut acreage is reduced by about 50% in Texas if the allotment program is replaced with a free market policy (Nieuwoudt, Bullock, and Mathia 1976b).

[10] Values of $P_e - P_o$ shown in table 1 are estimates for marginal increase in acreage. The value of $P_s - P_e$ decreases when acreage expands, since the supply curve is upward sloping. Thus, even if peanut acreage expands by 100% when allotments are removed, the total value of peanut land decreases where $P_s - P_e$ and $P_s - P_o$ are equal at the current allotment acreage.

allotments. If other inputs are also specialized, they too earn rents, and a price-support program affects the level of rents. In this case, the model loses some of its ability to predict the effect of a change in allotment rents on land prices, since any change in rents to specialized factors affects the prices of all such factors (not just land prices).

The basic rent model developed should be useful in analyzing differential effects of other price-support and allotment programs on land values by production region. It can easily be modified to analyze the effect of price-support programs where the allotment is made in units of output (poundage quota, milk base, etc.).

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Impact of Farm Size on the Bidding Potential for Agricultural Land: Comment

G. A. Whitmore

In a recent issue of this *Journal*, Harris and Nehring (H-N) present a theoretical model of the maximum bid price for agricultural land and an application of the model to cash-grain farms in Iowa. This comment identifies a numerical error in their work, which, when corrected, reveals a conceptual flaw in their model. A revised model is formulated and its application is illustrated using the H-N data.

The Harris and Nehring Model

H-N state their model in equation (1), where the maximum bid price per acre B is defined as the solution of the following expected utility equation:

$$u(x) = E\{u(x + z - B)\}, \tag{1}$$

where x is a fixed (i.e., nonrandom) level of assets, z is a random variable denoting the value of an acre of land, and u denotes the utility function of the farmer. To solve equation (1) for B, H-N use an approximation that requires the calculation of Pratt's measure of local risk aversion from the formula $r(x) = 0.6984/x$. For the asset levels reported in their table 1 for five classes of Iowa farms, the $r(x)$ values given in the same table are all in error by a factor of 1,000. Adjusting the $r(x)$ values by this factor and performing the requisite calculations, the risk premiums reported in their table 4 shrink by a factor of 1,000. For example, the risk premium for an acre of a class IV farm changes from \$77.04 to \$0.08. The latter figure is absurdly small and leads one to question the suitability of the H-N model.

The defect in the H-N model is found in equation (1). A proper formulation of this valuation model would acknowledge that x and z are correlated random variables. The variable x is random because the present value of future after-tax income from farm and nonfarm sources is risky, and x and z are correlated because the present value of after-tax income from an additional acre of land covaries with the economic value of the farming enterprise as a whole.

A Revised Model

In correcting the H-N model, it is helpful to adopt new notation. Let the economic net worth of the farmer, based on farm and nonfarm net incom sources, be denoted by random variable X, and le the after-tax value of an acre of land be denoted b random variable Z. The farmer's utility function fo wealth, measured in present value terms, is denote by u. Finally, p denotes the value of land and othe capital assets that are required (or released) by a expansion (or contraction) of a farm's size by on acre. The term "other capital assets" refers to in vestment changes in equipment and building necessitated by a change in the scale of operations

Given that the size of a farm can be altered at price of \$$p$ per acre, a change of m acres in a farm' size yields the following expected utility to th farmer:

$$E\{u[X + m(Z - p)]\}. \tag{2}$$

The value of equation (2) depends on the farmer' utility function u and the probability distribution o $X + m(Z - p)$. To keep the development simple suppose the utility function has the exponentia form $u(w) = -\exp(-rw)$ and that X and Z have bivariate normal distribution. Letting c denote th certainty equivalent of equation (2), its value unde these assumptions can be shown to be

$$c = E[X + m(Z - p)] - r\sigma^2[X + m(Z - p)]/2 \tag{3}$$

where E and σ^2 denote expectation and varianc operators, respectively, and r is Pratt's measure o local risk aversion (i.e., $-u''/u' = r$ when $u(w) = -\exp(-rw)$).

If the farmer's present amount of land is optimal then c should attain a maximum at $m = 0$. Using th properties of E and σ^2 operators to expand th terms on the right-hand side of equation (3) an setting the first derivative with respect to m equal t zero gives

$$E(Z) - p - r[\sigma(X, Z) + m\sigma^2(Z)] = 0, \tag{4}$$

where $\sigma(X, Z)$ denotes the covariance of X and Z. $m = 0$ corresponds to an extremum, then it mus satisfy equation (4). Setting $m = 0$ in equation (4 gives, after some rearrangement,

$$p = E(Z) - r\sigma(X, Z). \tag{5}$$

From equation (5), the marginal value of an extr acre of land (and the extra capital assets that ar needed to farm it) equals the expected value of a acre $E(Z)$ minus a risk premium $r\sigma(X, Z)$ that de pends on the farmer's risk aversion and th

G. A. Whitmore is a professor of statistics with the Faculty of Management, McGill University, Canada.

covariance between the value of the extra acre and the farmer's net worth.

Implications of the Revised Model

Equation (5) is the corrected analog of H-N's equation (9), which, in the notation of this paper, has approximately the following form:

$$B = E(Z) - r\sigma^2(Z)/2. \tag{6}$$

Contrasting equations (5) and (6), a number of differences are noted. First, B and p do not have synonymous interpretations. H-N incorrectly interpret B as the maximum bid price per acre, whereas it exceeds this price by the value of capital assets that are needed to farm an extra acre of land. Second, in H-N's formulation, the utility function u is a power function that makes the measure of risk aversion r dependent on the farmer's net worth. In the revised model presented here, the exponential function has been used in place of the power function to simplify the mathematical development. Conceptually, there is no difficulty in assuming that u and the probability distribution of $X + m(Z - p)$ have different functional forms than those assumed here. However, the adoption of other forms is likely to be accompanied by less tractable analytical results. In spite of the fact that r in equation (5) is assumed to be a constant for any specific farmer, it is free to vary among farmers so as to reflect diverse attitudes toward risk bearing.

Third, the major difference between equation (5) and (6), and the one that led to the revised model, is the magnitude of the risk premium. The risk premium of equation (5) tends to be substantially larger than that in equation (6) for the following reason. By definition, $\sigma(X, Z) = \rho\sigma(X)\sigma(Z)$, where ρ is the correlation coefficient of X and Z. The values of ρ and $\sigma(X)$ both depend on the proportion of the farmer's net worth derived from nonfarm income and also on the income tax structure, since X is computed on an after-tax basis. If the farmer's net worth derives almost completely from his farm operation, then ρ is close to one and, as shown later, the ratio of risk premium $r\sigma(X, Z)$ to risk premium $r\sigma^2(Z)/2$ is about two times the farm acreage. This explains why the risk premiums obtained from H-N's model seem unreasonably small.

Using equation (5), one can follow H-N's lead and study the *ceteris paribus* effect on p of differential changes in key parameters such as the marginal tax rate, the measure of risk aversion, and so on. Their analysis is not redone here because it is readily duplicated using equation (5) in lieu of H-N's equation (9). It is interesting, however, to consider some new insights into the theoretical aspects of their topic that are provided by the revised model but not by H-N's original model.

First, equation (4) can be rearranged to give a demand schedule for farm acreage m as a function of price p of the following form:

$$m = \frac{E(Z) - r\sigma(X, Z) - p}{r\sigma^2(Z)}. \tag{7}$$

The demand schedule is linear in p with a downward slope of $\$r\sigma^2(Z)$ per acre.

Next, observe that the certainty-equivalent value of the farmer's equity is

$$c = E(X) - r\sigma^2(X)/2. \tag{8}$$

This represents the minimum cash amount the farmer would accept for his ownership claim on the farm and nonfarm assets.

To present additional conceptual insights provided by the revised model, it is helpful to posit the nature of the functional relationship between X and Z. This also accommodates a subsequent numerical illustration. Assuming that a farmer has an n-acre farm with fixed debt obligations (valued after tax adjustments) of L, the farmer's equity is $X = nZ - L$. Since L can be viewed as nonrandom, this relation between X and Z implies that $E(X) = nE(Z) - L$, $\sigma(X, Z) = n\sigma^2(Z)$, and $\sigma^2(X) = n^2\sigma^2(Z)$. Thus, the certainty-equivalent value of the farmer's equity X, as defined by equation (8), is

$$c = nE(Z) - rn^2\sigma^2(Z)/2 - L. \tag{9}$$

Substituting $n\sigma^2(Z)$ for $\sigma(X, Z)$ in equation (5) gives the price per acre

$$p = E(Z) - rn\sigma^2(Z). \tag{10}$$

Using equation (10), equation (9) may be simplified to

$$c = np - L + rn^2\sigma^2(Z)/2. \tag{11}$$

Interpreting equation (11), the first term np represents the total market value of the n-acre farm. Subtracting L to obtain $np - L$ yields the market value of the farmer's equity. Finally, the term $rn^2\sigma^2(Z)/2$ represents the farmer's surplus, i.e., the excess of the certainty-equivalent value of the farm over its market value. The term "surplus" is used because it equals the triangular area under the demand schedule in equation (7) above the market value p.

An interesting by-product of the valuation model developed in this comment is a measure, albeit a crude one, of the bankruptcy risk of a farm operation. For the case in which $X = nZ - L$, bankruptcy occurs if $nZ < L$ because in this situation the economic worth of the farm is less than its liabilities. Since Z has been assumed to have a normal probability distribution, the probability of bankruptcy is found readily from normal probability tables given values for n, $E(Z)$, $\sigma(Z)$, and L. The calculation is illustrated below. Since the actual occurrence of bankruptcy involves complicated intertemporal dynamics, the measure of bankruptcy probability provided by this model must be viewed only as an approximation to the real risk of insolvency.

Table 1. Illustrative Valuation Results for Five Classes of Iowa Cash-Grain Farms and Farmers

	Farm Class				
	0	I	II	III	IV
Farm size (acres), n	1,307	630	390	254	170
Expected value per acre, $E(Z)$	439.25	567.17	520.64	426.04	308.21
Variance of value per acre, $\sigma^2(Z)$	6,815.5	11,363.2	10,306.5	6,507.8	10,499.4
Measure of risk aversion, r	2.98×10^{-6}	5.98×10^{-6}	6.99×10^{-6}	7.09×10^{-6}	14.67×10^{-6}
Price per acre, p	412.70	524.36	492.54	414.32	282.03
Risk premium per acre, $E(Z) - p$	26.55	42.81	28.10	11.72	26.18
Expected value of equity, $E(X)$	234,167	117,489	99,953	98,568	47,616
Certainty equivalent value of equity, c	216,813	104,004	94,473	97,079	45,391
Market value of equity, $np - L$	199,466	90,519	88,994	95,591	43,165
Surplus, $c - (np - L)$	17,347	13,485	5,479	1,488	2,226
Value of debt obligations, L	339,933	239,828	103,097	9,646	4,780
Expected value of farm, $nE(Z)$	574,100	357,317	203,050	108,214	52,396
Market value of farm, np	539,399	330,347	192,091	105,237	47,945
Bankruptcy probability, $P(nZ < L)$	0.015	0.040	0.006	0	0.003

Applying the Revised Model to Harris and Nehring's Data

It is informative to apply the formulas developed above to H-N's data on five classes of Iowa cash-grain farms. The numerical results should be considered as illustrative only, since, as H-N correctly point out, the data are unreliable in the extreme and are derived from many crude assumptions. The values of r used in table 1 have been adjusted by a factor of 1,000 to rectify the numerical error in the H-N article. The "net worth" value given by H-N is assumed to represent $E(X)$, the expected value of the farmer's equity. The assumption that $X = nZ - L$ eliminates explicit consideration of the tax structure and nonfarm income sources. In spite of the degree of abstraction involved and the shortcomings of the data, the numerical results still seem reasonable. The risk premium per acre varies from \$11.72 for a class III farm to \$42.81 for a class I farm (table 1). The surpluses for these farms range from \$17,347 to \$1,488, decreasing with the size of farm except for the smallest farm class. This means for a class 0 farm that \$17,347 in excess of its market value (based on a marginal valuation of its land and other capital assets) would have to be paid to purchase it. The size of farm debt obligations are surprisingly realistic given the oversimplified model used to derive them, i.e., the model $X = nZ - L$. Debt amounts increase steadily with farm size. For class III and IV farms, debt-equity ratios (based on the market value of equity) are quite small. For the three largest classes of farms, the debt-equity ratio ranges from 1.16 for a class II farm to 2.65 for a class I farm. The latter ratio seems too large and casts suspicion on H-N's data for this farm class. To illustrate the calculation of a bankruptcy probability, using table 1 for farm class 0, $nE(Z) = 574{,}100$, $L = 339{,}933$, and $n\sigma(Z) = 107{,}901$. Thus, nZ must fall more than $(574{,}100 - 339{,}933)/107{,}901 = 2.17$ standard deviations below its mean for bankruptcy to occur. Consulting a normal probability table gives the corresponding bankruptcy probability as 0.015. The bankruptcy probabilities for the five classes of farms are shown in table 1. As noted already, the debt-equity ratio for the class I farm is anomalous, and this accounts in part for the large bankruptcy probability for this class of farm.

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Impact of Farm Size on the Bidding Potential for Agricultural Land: Reply

Duane G. Harris and Richard F. Nehring

Whitmore's comment identifies a numerical error in our empirical illustration and contends that our bid-price model is thus conceptually inadequate. While there is indeed a mistake in our numerical illustration, although not the one Whitmore purports to discover, that error in no way invalidates the conceptual foundations of our model. Furthermore, in his extension of our model, Whitmore inadvertently contrasts the results of our bid-price model with a certainty-equivalent model. Finally, Whitmore's certainty-equivalent approach itself generates a questionable theoretical model.

The purpose of this reply is to acknowledge and clarify the numerical and reporting errors contained in the original paper and to evaluate Whitmore's theoretical criticism of our model. The numerical clarification is presented in the next section. Whitmore's theoretical argument is considered, a correct extension of the bid-price model is presented, and some final comments are offered.

Numerical Clarification

Unfortunately, our numerical illustration contains both a reporting error and a calculation error. The reporting error is the one that leads Whitmore to question the validity of our results. To make our analysis compatible with the LDM utility function, it is necessary to define wealth and income in thousands of dollars. In our calculations we did so. In table 1, however, we chose to report the results in dollars rather than thousands of dollars. Thus, the measure of risk aversion, $r(x)$, was reported as used in the calculations rather than as appropriate for income and wealth defined in dollars. While an incorrect measure of $r(x)$ was reported, the bid prices were correctly calculated and reported as far as the measure of risk aversion was concerned.

The calculation error involves an incorrect scaling procedure on variability of income per acre. We mistakenly scaled the variance of income in thousands of dollars rather than the standard deviation. Thus, the bid prices were in error, much as Whitmore contends, but for a different reason. Corrected per acre bid prices for classes 0, I, II, III, and IV are \$439.24, \$567.14, \$520.60, \$426.02, and \$308.13, respectively. None of the tentative conclusions regarding relative bidding potentials are changed. The same bid-price rankings remain among the five farm-size classes.

The most misleading interpretation of our numerical results is that the difference between the risk-neutral bid price and the risk-averse bid price is defined as the risk premium. That interpretation is not consistent with Pratt's framework, but our interpretation evidently leads Whitmore to question the theoretical underpinnings of the bid-price model.

Whitmore's Revised Model

To evaluate Whitmore's revised model and to contrast it with our bid-price model, it is useful to state the conceptual differences between a bid price and an ask price or certainty-equivalent price. In Whitmore's and our notation, for a given level of wealth x, the asking price for z, a risk, is given by Pratt's equation (3a):

$$u(x + c) = E\{u(x + z)\}, \tag{1}$$

where c is the minimum asking price or certainty equivalent of z. Equation (1) establishes the behavioral relationship that the decision maker's utility from original wealth plus the certain asking price for the risky asset is at least as great as the expected utility from the portfolio that includes the risky asset. The risk premium π is defined by Pratt as the expected value minus the certainty equivalent:[1]

$$\pi = E(z) - c. \tag{2}$$

As Pratt cautions, the minimum asking price c must be distinguished from the bid price B, given by Pratt's equation (3b):

$$u(x) = E\{u(x + z - B)\}. \tag{3}$$

Equation (3) establishes the behavioral assumption that the decision maker pays a price for a risky asset such that the expected utility of his resulting

Duane G. Harris is an associate professor of economics at Iowa State University, and Richard F. Nehring is a graduate student at the University of Maryland.

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[1] Our reference in table 4 to the risk premium as the difference between the risk-neutral bid price and the risk-averse bid price is not consistent with the framework outlined by Pratt. Our interpretation involved the quantity $[E(z) - B]$ rather than $[E(z) - c]$.

position is no less than the utility of his original wealth position, which does not include the risky asset. In his criticism of our bid-price model, Whitmore reverts to the development of a certainty-equivalent model. Although Whitmore's certainty-equivalent analysis offers some useful insights, it does not generate results equivalent to a bid-price model.

Whitmore contends that the basis for the conceptual flaw in our bid-price model is that the model does not consider initial wealth as a random variable and thus does not accommodate correlation between the risky asset and the original wealth position. He is correct in his assertion about our treatment of wealth as certain, but that property of the model hardly can be considered a conceptual flaw. Unfortunately, Whitmore's attempt to extend the bid-price model utilizes questionable procedures and produces theoretically questionable results.

Whitmore defines p as the "value of land and other capital assets required to expand a farm's size by one acre." From his equation (3), which gives the certainty-equivalent expression incorporating random wealth,[2] he derives equation (5) for p as

$$p = E(z) - r\sigma(x, z), \tag{4}$$

where r is the measure of risk aversion, $\sigma(x, z)$ is the covariance between x and z, and $r\sigma(x, z)$ is Whitmore's definition of a risk premium.

In deriving equation (5), Whitmore first maximizes his equation (3) with respect to m, the number of acres added to original wealth, and then sets m equal to zero in his solution for p. Maximization of equation (3) with respect to m gives the additional acreage m^* that maximizes the certainty-equivalent of the farmer's wealth position. But by then setting m equal to zero, Whitmore solves not for the value of land and other capital assets required to expand a farm's size by one acre but rather for the land price at which the farmer's existing wealth position is optimal. In his definition, m equals one, but in his optimization procedure, m equals zero. Thus, his solution value of p is inconsistent with his original definition of p.

Furthermore, he claims that his equation (5) is the corrected analog of our equation (5), which in his notation appears as his equation (6) and has the following form:

$$B = E(z) - r\sigma^2(z)/2. \tag{5}$$

But Whitmore's equation (6) is not our bid-price equation in his notation. It is his certainty-equivalent equation in our notation.

In addition, Whitmore's "corrected analog" produces a curious result for the case in which wealth is certain. His equation (5) can be rewritten as

$$p = E(z) - r\rho\sigma(x)\sigma(z), \tag{6}$$

where ρ is the correlation coefficient between x and z. From equation (6), if z is risky but wealth is certain—$\sigma(x)$ equals zero—Whitmore's risk premium is zero. In other words, Whitmore is saying that, if wealth is certain, there is no risk premium on a risky asset, regardless of the degree of risk aversion of the investor. That result, as a special case of the general result in his equation (5), makes the model suspect.

Random Wealth and the Maximum Bid Price

To extend our original bid-price model to accommodate uncertain wealth and its correlation with the risky asset, a random element can be introduced into the initial wealth position. Let

$$V = x + v, \tag{7}$$

where x is now the beginning-of-period net worth of the decision maker and v is the random dollar change in his beginning-of-period net worth position over the period. Thus, V is the random value of beginning wealth as measured at the end of the period. Assuming

$$E(v) = 0 \tag{8}$$

and defining

$$\text{var } v = \sigma_v^2, \tag{9}$$

then

$$E(V) = x \tag{10}$$

and

$$\sigma_V^2 = \sigma_v^2, \tag{11}$$

where $E(V)$ and σ_V^2 are, respectively, the expected value and variance of the investor's initial wealth position at the end of the period; that is, the investor expects that, on average, the end of period value of his beginning net worth is equal to its beginning value. Also, if we assume that the investor purchases m acres of land, the bid price per acre is given by the equation

$$E[u(x + v)] = E[u(x + v + mz - mB)]. \tag{12}$$

Equation (12) establishes the behavioral assumption that the decision maker pays a price for a risky asset such that the expected utility of his resulting wealth position is no less than the expected utility of his original wealth position, which did not include the additional risky asset. The assumption is made that the investor does not alter his existing portfolio other than to purchase the asset mz.

By using a Taylor series to expand u around x and by utilizing Pratt's measure of local risk aversion,

$$r(x) = -\frac{u''(x)}{u'(x)}, \tag{13}$$

[2] Whitmore's derivation of the certainty-equivalent equation (3) involves truncating the Taylor expansion on one side of the equation after the linear term but on the other side after the quadratic term. All our derivations include the quadratic term on both sides of the equation.

equation (12) may be approximated by

$$(14)\quad \tfrac{1}{2}mr(x)B^2 - [mE(z)r(x) - 1]B + \left[\tfrac{1}{2}mr(x)\left\{\left[\sigma_z^2 + \frac{2}{m}\rho\sigma_v\sigma_z\right] + [E(z)]^2\right\} - E(z)\right] = 0.$$

Solution of this quadratic equation gives B in terms of $r(x)$, $E(z)$, m, σ_z, σ_v, and ρ:

$$(15)\quad B = E(z) - \frac{1}{mr(x)} \pm \left\{\frac{1}{[mr(x)]^2} - \left[\sigma_z^2 + \frac{2}{m}\rho\sigma_v\sigma_z\right]\right\}^{\frac{1}{2}} \text{ for } r(x) \neq 0;$$

$$B = E(z) \text{ for } r(x) = 0.$$

Incorporation of random initial wealth in the bid-price model results in a new formulation of our original equation (5), which includes the term $-\frac{2}{m}\rho\sigma_v\sigma_z$ in the square root portion of the bid price. Thus, as the covariance between initial wealth and the risky asset increases, the maximum bid price for the risky asset decreases. This is consistent with the thrust of Whitmore's argument. Also, if original wealth is certain—σ_v equals zero—equation (15) collapses into our original equation (5) for the case in which m equals one. Thus, the bid price for one additional acre for the certain wealth situation is but a special case accommodated by the more general bid-price model in equation (15). (For a more extensive discussion of the properties of a bid-price model under wealth uncertainty, see Harris and Hampel.)

Concluding Comments

Whitmore criticizes our development of a model in the context of a certain original wealth position. We agree that investors' wealth positions are likely to be uncertain, and thus we compliment Whitmore on the spirit of his extension of our model. In the exposition of his numerical results, however, Whitmore's assumptions become as contrived as ours. Specifically, he considers the situation in which a farmer sells one acre of land in order to buy an identical one.

Also, as noted, the difference between the bid price and the expected value of a risk does not represent the risk premium. Other research indicates that the bid price for a risk averter can be either greater or less than the expected value, depending upon the relative risk associated with the original portfolio as opposed to the new risk. (See Hampel and Harris for an elaboration of the relationship of the bid price to the expected value of a risk.) Thus, Whitmore's assessment that our risk premiums are "absurdly small" becomes irrelevant because we did not derive risk premiums as defined by Pratt.

Finally, there are many theoretical and empirical issues yet to be settled in the formulation of bid prices. For example, our model, even as modified, suffers from an inappropriate treatment of income taxes and from an awkward handling of the opportunity cost of equity. Whitmore has pursued an important extension of our original model. Adams and Hampel and Harris have likewise made inroads into some of the issues. But there is certainly much room for additional analysis if bid-price models are to offer richer insights into the ownership structure of and investment strategies for participants in U.S. agriculture.

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Transfer of Development Rights: An Analysis of a New Land Use Policy Tool: Comment

Mark R. Bailey and Clayton W. Ogg

In view of the large number of innovative land preservation measures that have recently been proposed, Barrows and Prenguber's attempt to identify possible economic problems of a transferable development rights (TDR) program is both interesting and timely. Their discussion, however, enumerates a number of problems that appear to make such a program virtually unworkable. The TDR program as conceived by the authors hardly compares favorably to other preservation measures being considered by planners and policy makers across the country (Bryant, Sargent). Many of the problems specified by Barrows and Prenguber (B&P) are not necessarily inherent in the TDR program per se but rather result from the assumptions and restrictions they employ. Following some specific criticisms of the B&P arguments, a static model is offered in an attempt to suggest more realistic problems and research needs concerning implementation of TDR programs.

The major criticism that B&P offer is that fair or full compensation would not be guaranteed to restricted land owners under a TDR program. Other criticisms center upon potential monopoly problems, forecasting locational demands, timing problems, and discontinuous supply curves. B&P's discussion of these problems is somewhat incorrect. They base most of their objections to a TDR program upon a rather limited analysis of a highway interchange system and then generalize from that analysis to criticize any TDR program. The weakness of some of their arguments results from this extrapolation.

B&P mention two problems on the supply side: the monopoly potential and the possibility of a noncontinuous supply curve. Both of these problems are moot. For a monopoly to form, an individual entity would have to gain nearly total control of the TDR supply. But it is difficult to believe that a potential monopolist could convince all holders of TDR to sell to him. Besides, market regulation could be designed to preclude such an occurrence. It is therefore unclear why the potential for monopoly in a TDR program is greater than it would be in the normal land market.

Mark R. Bailey and Clayton W. Ogg are agricultural economists with the Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture.

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Why is a noncontinuous supply curve a special problem? The authors suggest that market uncertainties would result in a noncontinuous supply curve because some DR owners would hold their rights, while less liquid or lower income holders would sell. But such actions are not unique to a TDR market. Does not the same thing occur in the stock market or in commodity trading?

The authors discuss at length possible timing problems in a TDR market brought about if owners of TDR do not sell when there is demand for those TDR. But under less restrictive assumptions, which they eloquently bring to light, timing problems evaporate. A criticism directed toward a TDR program should concentrate on those problems that are unique to the program rather than on those points that are pervasive throughout present land markets. TDR programs are, in fact, designed to ease several land market problems, such as the timing of land use changes, which the authors describe as if they are caused or exacerbated by a TDR program! In particular, TDR land use designations remove land development uncertainty that often precipitates erratic buying and selling.

The value of a TDR is dependent upon development demand, for it is that demand that gives rise to the difference in value between potentially developable land and restricted land. With a weak demand for development, the divergence in value between the two categories of land would be minimal, and thus little compensation would be required. This point is made in B&P's note 3. Nonetheless, B&P contend that professional planners must somehow anticipate where future developmental demand will be strong, so that they can designate those areas as development districts. Such designations, they argue, would guarantee a strong demand for TDR and thus provide fair compensation to the restricted landowners. However, in designating development districts based upon developers' wants, the shoe is on the wrong foot. Planners should first concern themselves with recommending socially optimum development patterns based upon soil capabilities, slope, access to public services, etc. Areas need not and, in many cases, should not be designated strictly according to estimates of prospective developers' locational wants. This is not to say, however, that planners should ignore developers' wants; rather, the primary designation criterion should not necessarily be based upon those wants.

Based upon their model, B&P conclude that for full compensation to be gained by the restricted property owners, unstable TDR prices would have been required. But in their note 12, they state that after the highway interchange was constructed, land assessments were still based upon agricultural values. This explains much of the price divergence of their TDR. Given the fact that TDR are homogeneous and perfectly substitutable, if each property had been assessed according to its locational and physical characteristics, full compensation does not suggest that TDR prices would be unstable. B&P's TDR price divergence would have been minimal; instead, prices of the land would have been divergent because of the advantageous characteristics of some parcels relative to others.

The question of full compensation is dependent upon full and accurate assessments. This point can be clarified with a static model. The model is also relevant to the closely related issue of anticipating development demand. It becomes evident that the example used by B&P involved assumptions that maximized potential TDR problems.

Limiting land designations to density zoning is an unnecessary assumption that adds to the lengthy B&P list of problems, particularly in anticipating development demand. There is no reason to carry this limitation of zoning into a TDR program. Assuming instead that the planning agency simply designates specific areas that should be developed or preserved, the supply of TDR can be based upon the potentially subdividable acres, strictly on an acreage basis.[1] Under this scenario, zoning is handled separately from the land designation under a TDR program. This separates land preservation from other decisions that affect land values.[2]

Like B&P's model, TDR will separate builders' demand for land and allow the right to develop land to be sold separately from the remaining rights to use the resource. The demand curves in figure 1 illustrate the separation of the two demands: D_t represents the original demand for land with all rights included, and D_f represents that portion of demand for land which is due to its potential returns from farming.

Figure 1 sets the original supply of developable land at S_1 with S_2 acres remaining after a TDR program has been implemented. Assuming for the moment homogeneous land acres, a TDR program allows losses in land value in the restricted areas, which are indicated by the cross-hatched rectangle in figure 1, to share some of the benefits in the area where values have increased (represented by the shaded area).

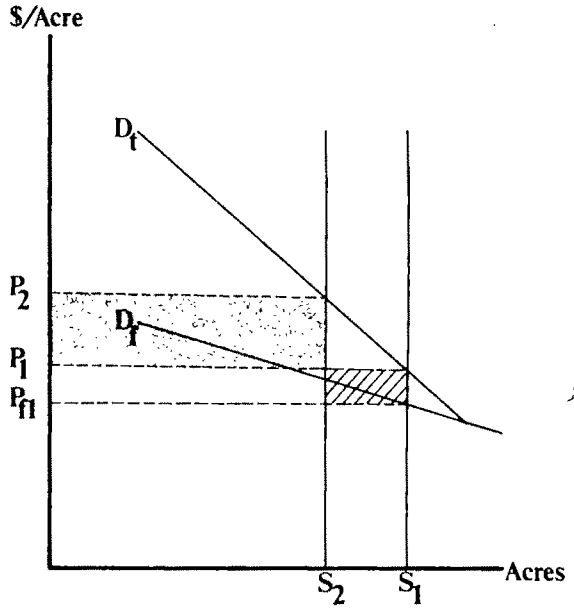


Figure 1. Economic consequences of preserving farmland

Under our assumptions, P_{f1} and P_2 are determined by demand curves that are not shifted by the preservation program.[3] However, P_2 is not itself the price of unrestricted land, for it includes the price of such land and the value of development rights. It is not clear how this value of unrestricted acres is divided between these two markets, although it would be a simple matter for the government to set some price, P_1 for instance, for unrestricted land. This would assure $P_2 - P_1$ as the price for development rights and make it possible for the benefits from the program to be divided between restricted and unrestricted landowners.

Designation of the correct number of TDR to meet overall housing demand clearly ceases to be a major problem, since unrestricted acres can be used in varying intensity according to the demands prescribed by developers.

The potential for economic losses due to downzoning also becomes very manageable by careful designations of land use to maximize the net of losses and gains between restricted and unrestricted areas. (Net gains equal the difference between the shaded area in figure 1 minus the cross-hatched area.) Since rights to the unrestricted acres are divided among all landowners, they share a common economic interest in obtaining social optimum land use designations for their community. If

[1] This correspondence between numbers of development rights and numbers of acres should not be confused with the distribution of these transferable development rights. Fair compensation depends completely on the way this homogeneous commodity is distributed.

[2] While this is more precise than zoning as a means of achieving land preservation objectives, it leaves part of the task of land use control within the "unrestricted area" to traditional zoning methods.

[3] We assume zoning decisions are separate from the TDR program. For representing the final demand for land, use of D_t in figure 1 still involves a simplification in that it ignores the impact of land preservation in raising the utility of owning units of the remaining land (Ogg). This demand shift is not emphasized here, since it does not serve to clarify our differences with Barrows and Prenguber. (It is assumed, of course, that restricting land from development does not appreciably change the supply of land that can be used for other nondevelopmental uses).

land use designations are based upon physical and aesthetic capabilities of the land and if demand for development rights is inelastic, positive net gains to landowners will result. This is true even where substantial acreages are totally restricted.

It should now be even more evident that, since development rights are still a completely homogeneous commodity, prices that owners receive will not vary as they did before DR were separated from the land. If the DR are equitably distributed, a common price for DR does not lead to the unfair losses predicted by B&P for owners in the restricted area.

Although certain criticisms of TDR made in B&P's article have been discredited here, a real difficulty appears when our rather unrealistic assumption of homogeneous acres is dropped. Different landowners start with very different property values due to unique locational and environmental capabilities for development and in land capabilities for other uses. Thus, the problem centers upon the equitable distribution of TDR to landowners.

The most important need for a workable TDR program is the accurate assessment of the value of each individual's original or preprogram development rights so that each may be assigned a fair share of the TDR. Fortunately, land assessment is not a new problem; by focusing on this real need, initiation of a TDR program does not appear to be such a hopeless task.

It is evident that success for TDR may still depend upon fairly restrictive local circumstances and that it may not be economically feasible for many situations where land use control or preservation is desired. TDR may never be politically acceptable anywhere. Nonetheless, careful anticipation of economic impacts under well-defined conditions is a more positive approach than simply listing every possible thing that can go wrong under any hypothetical program or circumstance.

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Transfer of Development Rights: An Analysis of a New Land Use Policy Tool: Reply

Richard L. Barrows, Bruce A. Prenguber, and Marvin B. Johnson

We agree wholeheartedly with Bailey and Ogg that "careful anticipation of economic impacts" of TDR is a productive and necessary step in refining the promising concept of TDR. Since the theoretical advantages of TDR have been widely discussed and accepted, researchers should focus on identifying (and solving) the practical problems that may arise in initiating and administering TDR programs. In the initial article, the economic determinants of success in establishing and administering a TDR program were identified, and the impacts of a hypothetical program around a highway interchange were analyzed. The article was not normative—the purpose was not to "object" to TDR nor to show that TDR is necessarily unworkable as a land use policy. The analysis of the highway interchange TDR program revealed several practical and theoretical difficulties that arose when TDR was applied to the complex realities of the development process, and it was suggested that additional research is needed to simulate TDR programs in other environments.

While we agree with Bailey and Ogg that potential TDR impacts should be carefully analyzed, we fear they have misinterpreted much of the argument. First, it was not claimed that DR monopoly would necessarily plague all TDR programs, but we strongly disagree that the potential problem is "moot." If the preservation area is relatively small, or if a large preservation area is held by only a few owners (e.g., farmers), there is certainly potential for one owner to amass a large portion of the outstanding DR. Decision makers wishing to implement TDR programs should not ignore potential DR monopoly problems simply because there may already be monopoly elements in the current development land market.

Second, a TDR program would not necessarily be characterized by a noncontinuous DR supply schedule, nor would such a schedule necessarily doom the program. Instead, it was argued that the "uncertainties of market action by DR holders may not permit the assumption that DR supply will be a continuous positively sloped curve" and that decision makers (and economists) should be aware of this in establishing or analyzing TDR programs (p. 551). Potential problems of the timing of DR supply and demand were noted, and it was argued that these problems could exacerbate current timing problems in the market for development land.

Third, Bailey and Ogg imply that there is no need for planners to anticipate development demand to ensure strong DR prices and "reasonable" compensation. Rather, they argue that if development demand is weak, there is only slight divergence between development and restricted values of land, and very little compensation is required. Clearly, if there is no demand (or weak demand) for developable land, there may be little reason for establishing a TDR program. But the critical question is: How does the DR price compare with the loss of development value incurred by the restricted landowner? It is this comparison that may be used by the courts and the community to determine whether the compensation is "fair." Consider the following cases of TDR development districts (DD) and preservation districts (PD).

(*a*) Small DD, small PD: the planning agency must forecast development demand with some accuracy and establish the DD accordingly. Otherwise, developers may avoid the relatively small DD, and restricted landowners would not be compensated.

(*b*) Small DD, large PD: again, the planning agency must establish the DD such that strong development demand results in compensation to restricted owners. However, the large PD may require that many DR of substantial aggregate value be purchased to ensure compensation.

(*c*) Large DD, small or large PD: unless truly massive urbanization is underway, development may occur many years into the future at the low density that may be permitted in the DD without DR purchase. Compensation may be delayed many years and may jeopardize the legality of the restrictions.

Thus, the problem of low demand for development in the DD cannot be dismissed by the simple argument that low demand necessarily means little compensation is required. In each of the above cases, the development potential in the preservation district might have been quite high prior to the TDR program, yet low DR demand would provide little compensation.

Fourth, the finding that full compensation would have required fluctuating DR prices seems to be quite disturbing. We agree that full compensation

Richard L. Barrows is an associate professor and Marvin B. Johnson is an assistant professor in the Department of Agricultural Economics, University of Wisconsin—Madison, and Bruce A. Prenguber is a natural resource economist with the Washington Department of Natural Resources, Olympia.

does not invariably or logically require fluctuating DR prices, but the question can only be answered by empirical analysis. The fact that DR are perfectly substitutable for each other and that land prices vary does not imply that DR prices "need not fluctuate." In the highway interchange analysis, if the posthighway land assessments had reflected locational value, full compensation DR prices may not have diverged so greatly. The uncertainty arises from the question of whether there were very great inherent differences in locational value among the farmland parcels on the interchange. The different per acre prices that were paid by developers may only reflect differences in bargaining skills, liquidity positions, or other "imperfections" in the market.

However, Bailey and Ogg argue that if locational differences are incorporated in land assessments, DR prices would have shown only "minimal" fluctuations. There is no empirical evidence offered to substantiate this claim. This argument is apparently based on the assumption that the interchange land market (and development process) behaves as the neoclassical model of pure competition suggests; hence, any deviation from the predictions of that model must be due to the researcher's error. We maintain that the stability of DR prices can only be established through empirical analysis of potential (or preferably actual) TDR programs.

Finally, Bailey and Ogg argue that "criticism directed toward a TDR program should concentrate on those problems that are unique to the program." Again, it is incorrect to conclude that the original analysis was a normative criticism of TDR. In any case, it is not clear why an analysis of TDR should be limited to those features unique to the program. If TDR success depends on estimating the strength and timing of development demand, or if property tax assessments are used in distributing DR, then problems with the land market or tax assessment system may doom the program just as surely as problems "unique" to TDR, such as excessively low DR prices or court decisions on TDR's constitutionality.

A troublesome aspect of Bailey and Ogg's argument is the attempt to separate zoning and density from the TDR program. They argue that "zoning is handled separately from the land designation under a TDR program" but also note that "it [TDR] leaves part of the task of land use control within the unrestricted area to traditional zoning methods." This distinction is unclear. Hopefully, a community's land use plan is the basis for designation of preservation and development districts, but the essence of TDR is density restrictions in the development zone that create demand for DR and lead to compensation for restricted owners. It matters little whether these area designations and density restrictions are termed "zoning," but the restrictions are critical to TDR success.

The graphical model advanced by Bailey and Ogg is an interesting application of price theory and illustrates the economic gains and losses in TDR programs. However, the assumptions of the model require more scrutiny, and its usefulness is limited by its static nature.

The meaning of the model's demand curves is unclear. For example, it is assumed that land is homogeneous, yet the farm component (D_f) of total demand (D_t) is represented as downward sloping in figure 1. Why are the potential returns from farming homogeneous acres within a relatively small TDR region declining rather than constant? The nonfarm component of total demand for land is even more confusing. This implicit development potential component to D_t is never identified but presumably represents the discounted present value of the possible future gains associated with developing land rather than farming it. The downward slope of the implicit development demand component can be attributed to differences in owners' and developers' perceptions of future development potential. The homogeneous acres are then ranked along the horizontal axis according to the views (optimistic to pessimistic) of the area's development potential. Alternatively, the demand for development land may be viewed as the perceptions of a single developer extracting all consumer surplus from the development process.

The development component cannot possibly reflect actual demand of development land. If such a demand existed at the time restrictive zoning or TDR was being considered, it would have been realized before any program went into effect. Farmers who hold land at P_1 (or P_2) are speculating that their land will someday be purchased by a developer for considerably more than its farming value. This is implicitly recognized when the farm and development components are vertically added to derive the total demand curve. Such vertical addition requires that the homogeneous acres be identified and ranked. Bailey and Ogg are correct to note that a "real difficulty appears when the assumption of homogeneous acres is dropped." We suspect that a model that adds demand curves horizontally and analyzes the specific acreage allocation to different uses may be more appropriate and useful in analyzing TDR programs. Finally, the assumption that the demand curves do not shift with the onset of TDR must be carefully examined. What area do the curves represent, and what happens if there is any area avoidance by developers? The assumptions of Bailey and Ogg's model certainly deserve more scrutiny, but the model is a first step toward a general theory of TDR markets.

Great care must be taken in discussing the benefits of a TDR program. Bailey and Ogg seem to equate "social optimum land use designations" with maximizing the difference between the gain in aggregate land value in the development zone and the loss in aggregate land value in the preservation zone. This is correct only if private demand for development is based on all social benefits and costs inherent in the development process. But if this were the case, there would be no efficiency

gains from public policies to control land use. Land use controls allocate land through a nonmarket process precisely because the "social optimum land use" pattern does not result from unrestricted private individuals responding to market signals. In terms of Bailey and Ogg's model, the private development demand curve does not reflect the net social benefit from land development. Alternatively, the suggestion that the local government maximize the "net of gains and losses between restricted and unrestricted areas" is equivalent to the dictum that the local government should maximize aggregate land value in the area. In this view the local government acts as a monopolist who sets development land supply to maximize aggregate land value, equivalent to "social optimum land use" only if the development demand curve represents social rather than private returns to development.

While Bailey and Ogg focus on the aggregate benefits and costs of TDR, we believe that the more critical issue is the incidence of benefits and costs. TDR has appealed to many planners and local governments because its cost to government seems to be zero (ignoring administrative costs). While TDR may mean a "free lunch" for local government, someone pays for the change in land policy. The distribution of TDR costs among restricted zone landowners, development zone landowners, developers, and final consumers is not clear (Barrows and Prenguber). The distribution of benefits and costs of TDR programs is a fruitful area for future research.

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Welfare Implications of Stabilizing Consumption and Production: Comment

Robert Weaver and Peter Helmberger

In a recent paper Subotnik and Houck consider previous theoretical analyses that compare the effects of price instability (no storage) with the effects of price stabilization (storage) and conclude that price stabilization gives rise to an increase in welfare if one is willing to ignore storage costs. Subotnik and Houck claim this result could be used to justify using buffer stocks. We fail to see how a model that ignores storage costs can be used to justify buffer stocks, public or private. Moreover, welfare analysis of government-held buffer stocks must compare outcomes of regimes with and without government, not with and without storage. Clearly, private storage and speculation may occur in the absence of a government buffer stock scheme.

This brings us to a more important concern with the Subotnik-Houck paper. They propose to extend previous work through analyzing the welfare effects of stabilizing consumption and production. Their model of a free and competitive market assumes that private storage and speculation do not occur. This can be seen most clearly by the manner in which expressions for equilibrium price and quantity are developed. Supply and demand are equated in the tth period, with no consideration given to storage. A model that disallows private storage when the commodity involved is storable is not a model of a free and competitive market and appears to be of limited interest.

If private storage is allowed, then the buffer stock transactions undertaken by the government to stabilize consumption or production, as proposed by Subotnik and Houck, are in error. The reason for this is that the stabilization of consumption (production) gives rise to price instability. Instances might easily arise in which the difference between the current and expected future price exceeds per unit storage costs, which in turn leads to private storage. One can easily think of examples in which the proposed government transactions would be offset by those of the private trade. Consider a situation in which demand is very weak. In order to stabilize consumption, the government sells from its stock, thus depressing price. The private trade looks at the current price and decides that the expected price next year exceeds current price plus storage costs. Therefore, they acquire stocks at the very same time the government is selling its stocks. The government may not be able to achieve its objective.

In modeling government policy that seeks to stabilize variables other than price, Subotnik and Houck have given inadequate attention to the possibility of private storage. The buffer stock transactions that the government uses to achieve its objective must take into account the behavior of the private storage industry. When this is recognized, it is by no means clear that non-price stabilization is a viable government alternative. Writers who have focused on price stabilization have been able to ignore private storage because with positive per unit storage costs, complete price stabilization destroys the private storage industry.[1] It seems imperative that theoretical analysis pay attention to the behavior of private traders if the resulting hypotheses are to be useful in understanding what goals the government might strive to achieve, what buffer stock transactions it might choose to use, and what impact its actions might have on market performance.

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Robert Weaver is a graduate student and Peter Helmberger is a professor in the Department of Agricultural Economics, University of Wisconsin, Madison.

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[1] Massell has constructed a model of an international buffer stock scheme, assuming zero storage costs and allowing for varying levels of price stabilization. Unfortunately, he, too, neglected the possibility of private storage and speculation in the construction of his formal model. This renders many of his theoretical results for other than the complete stabilization case of limited interest.

Welfare Implications of Stabilizing Consumption and Production: Reply and Extension

Abraham Subotnik and James P. Houck

The purpose of the article criticized by Weaver and Helmberger was not to exhaust reality but to extend the theoretical analysis of stabilization schemes. We wished to see how the already known, abstract measures of welfare and variability change when quantities, not prices, are stabilized by central authority. To introduce private storage explicitly obviously changes the model and damages simple analytical comparisons with previous work. Moreover, one can easily imagine an economy in which private storage (in the commercial sense) is either illegal or heavily taxed. However, the role of private storage is important in an open market economy, and its consideration will lead to a more realistic appraisal of stabilization schemes.

Before formally introducing private storage into the model, we flatly contradict the statement by Weaver and Helmberger that our results are in error because the stabilization of quantity may destabilize price. We say explicitly that "supply stabilization may result in either increased or decreased price variability" (p. 17). The results may lack a measure of realism, but they are not erroneous; at least, Weaver and Helmberger have not shown it.

The core of the Weaver-Helmberger comment concerns the absence of commercial stocks. They imply that the existence of private speculation may preclude the government from operating quantity stabilization schemes. Including commercial stocks in our analysis does not affect the abstract measures of benefits to producers, consumers, and society from the different stabilization schemes that were analyzed. They are correct in arguing that the existence of commercial stocks will affect the budgetary aspects of different stabilizing schemes. As will be shown, this implies a transfer of income between government and speculators. In some cases, private speculation would hamper though not necessarily preclude a quantity stabilization scheme.

Following Working, Brennan, and, more recently, Peck, we specify the relevant portion of the supply of storage function as

$$M_t = \gamma(P^* - P_t) \text{ for } \gamma \geq 0, \tag{1}$$

where M_t is commercial demand for (supply of) speculative stocks at time t, P^* is expected price, and P_t is current price at time t. This relation shows that, as the expected price rises relative to current price, commercial demand for speculative inventory increases. (We abstract from pipeline or convenience stocks required for commerce.) If current price exceeds expected price, M_t becomes negative and can be viewed as a current supply of speculative stocks out of private storage. But in the rational price expectation context, current prices are unbiased estimates of the equilibrium expected price. Therefore, the expected level of commercial demand for (supply of) speculative stocks is zero. Since the equilibrium expected price is known, equation (1) says that speculators take advantage of unanticipated differences that occur between current and equilibrium expected prices as the result of various random shocks.

Since the expected commercial demand for speculative stocks is zero, the expected equilibrium prices and quantities are not affected by their inclusion. Therefore, the expected benefits to consumers and producers from various stabilization schemes are not affected by including speculators in the analysis.

Demand Stabilization

The existence of speculators affects the cost of government of the stabilization schemes. Consider the basic model stated in equation (1) of the original article. The rational price expectation approach implies

$$P^* = \frac{\alpha_0 - \beta_0}{\alpha_1 + \beta_1}. \tag{2}$$

The change in government stocks when demand is stabilized is given by

$$\Delta G(D_s)_t = S(D_s)_t - D_s - M(D_s)_t, \tag{3}$$

where $S(D_s)_t$ is given by equation (14) in the original article and D_s by equation (13). When demand is stabilized, the speculative holdings of stocks are

$$M(D_s)_t = \gamma(P^* - P(D_s)_t) = -\frac{\gamma}{\alpha_1} u_t. \tag{4}$$

The change in government stocks is

Abraham Subotnik is with the Faculty of Industrial and Management Engineering, Technion-Israel Institute of Technology, Haifa, Israel, and James P. Houck is with the Department of Agricultural and Applied Economics, University of Minnesota.

$$\Delta G(D_s) = v_t + \frac{\gamma}{\alpha_1} u_t, \tag{5}$$

compared with only v_t without speculation. Consider the expected speculative profits when demand is stabilized. These expected profits are

$$E\,\Pi(D_s) = E\{(P^* - P(D_s)_t)(PS(D_s)_t)\} = \frac{\gamma}{\alpha_1^2}\sigma_u^2, \tag{6}$$

where $(D_s)_t$ is speculative profits at time t when government stabilizes demand. Letting $R(D_s)$ be the expected government deficit when demand is stabilized, it can be shown that

$$R(D_s) = \frac{\gamma}{\alpha_1^2}\sigma_u^2. \tag{7}$$

The original analysis of this case showed that, when demand was stabilized and no speculation existed ($\gamma = 0$), the scheme was neutral in its budgetary aspects. When speculation is allowed, the government runs a deficit that is actually a transfer payment to speculators. If only the supply function is unstable in this case, there are no gains to speculators and no extra costs to government.

Incidentally, the storage capacity needed by speculators to handle 95% of all possible cases is $1.96(\gamma/\alpha_1)\,\sigma_u$ if the random elements are normally distributed.

Supply Stabilization

The change in government stocks when supply is stabilized is given by

$$\Delta G(S_s)_t = S(S_s)_t - D(S_s)_t - M(S_s)_t, \tag{8}$$

where $S(S_s)_t$ and $D(S_s)_t$ are given by equation (21) in the original article. The commercial holding of stocks when supply is stabilized is

$$M(S_s)_t = \gamma(P^* - P(S_s)_t) = \frac{\gamma}{\beta_1} v_t. \tag{9}$$

It follows from equations (8) and (9) that

$$\Delta G(S_s)_t = \left[1 - \frac{(\alpha_1 + \gamma)}{\beta_1}\right] v_t + u_t. \tag{10}$$

The expected gains of the speculators when government stabilizes supply are

$$E\,\Pi(S_s) = E\{(P^* - P(S_s)_t)(PS(S_s)_t)\} = \frac{\gamma}{\beta_1^2}\sigma_v^2. \tag{11}$$

Letting $R(S_s)$ be the expected government deficit when supply is stabilized,

$$R(S_s) = \frac{\alpha_1 + \gamma - \beta_1}{\beta_1^2}\sigma_v^2. \tag{12}$$

Compare this result with that obtained when no speculation was assumed. If $(\alpha_1 + \gamma) > \beta_1$, the expected government deficit is larger by $\frac{\gamma}{\beta_1^2}\sigma_v^2$. On the other hand, if $(\alpha_1 + \gamma) < \beta_1$, the government surplus is smaller by the same amount. Clearly, if only demand is unstable, the expected change in the government deficit is zero whether speculation is present or not.

Assuming that the random elements are normally distributed, the size of storage capacity needed by speculators to handle 95% of all possible cases is $1.96\frac{\gamma}{\beta_1}\sigma_v$.

In conclusion, speculative profits are equal to the increased cost to the government when speculation exists. From the social point of view, these increased costs are transfer payments from taxpayers to speculators and, in principle, are recoverable.

A general analysis shows that some of the time the government would be working against the private trade in pursuit of a simple quantity stabilization goal. Sometimes both would be working in the same direction. That surely is nothing new. But in the presence of private speculation on a large or potentially large scale, a reformulation of the quantity target considering both current consumption and inventory demand surely would be sensible.

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Institutional Affiliation of Authors of Contributions in Agricultural Economics, 1968–72

James Opaluch and Richard E. Just

Holland and Redman provide a survey of the affiliation of authors contributing to this *Journal* (*AJAE*), arguing that "*AJAE* contributions . . . represent one of several important indicators of departmental quality" (p. 784). In a later comment, Finley pursued their approach but argued that the Holland and Redman accounting does not allow for variation in departmental size. In other words, a smaller department may publish less than a larger department but still publish more per member.

In this note, two additional factors are considered in measuring departmental productivity of refereed published research.[1] These two considerations relate to Finley's method of computing output per member without regard to graduate student or professional status and to the agricultural economics research that is published in journals other than the *Journal*.

In the *Handbook-Directory* data Finley used to measure departmental size, graduate student and extension components of membership are highly variable among departments. In other words, if a large percentage of graduate students are members of the American Agricultural Economics Association (AAEA), a small department may appear as a relatively large one. Hence, to hold the same relative rankings, graduate students would have to publish at the same rate as faculty. In effect, Finley's method penalizes those departments that are successful in generating AAEA membership interest among their students (assuming faculty is more prolific than graduate students).[2]

Hence, the 1972 *Handbook-Directory* was used to determine whether each member was a part of the department's teaching-research faculty or was primarily of graduate student status. Since those with extension appointments may not be expected to produce refereed published research, a separate accounting was also made for those primarily involved in extension.[3] Nonstudent U.S. Department of Agriculture personnel are considered along with teaching-research faculty, since they likely contribute to the *Journal* more than graduate students. For those few members for whom the 1972 directory did not include status, the 1966 *Handbook of the American Farm Economics Association* was consulted. Student membership in 1966 was assumed to imply faculty status by 1972; otherwise, if the 1972 status was unknown, the individual was included in the graduate student total. Although this measure of departmental size is still far from perfect, the totals should now be much more reflective of the number of persons holding positions in which refereed published research is expected.

The revision in departmental size measures is evident in table 1. Considerable changes in size are implied when only teaching-research faculty is considered as well as when extension staff is included. Apparently, the earlier membership figures were somewhat misleading in terms of faculty size. For example, Finley's calculations show forty-two AAEA members at the University of California—Berkeley and forty-six at University of California—Davis in 1972, implying nearly the same departmental size. Further investigation, however, indicates that there were fourteen teaching-research faculty members at Berkeley and twenty-six teaching-research faculty at Davis or nearly twice as many at Davis as at Berkeley. The difference with Finley's figures is due to the fact that the smaller department had greater membership among graduate students, not only relatively but also absolutely.

Using the new departmental size measures, the deflated or per person published output in the *Journal* is given in table 2.[4] Since it was not possible to

James Opaluch is a research assistant and Richard E. Just is an assistant professor of agricultural and resource economics, University of California, Berkeley.

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[1] Departmental productivity includes other forms of research than refereed publications, e.g., seminars, symposia, congressional publications, etc. However, refereed journal articles usually grow out of the most original and creative papers of other types and, as such, are a better measure of quality research.

[2] Finley admits this possibility but argues that graduate student membership will probably influence its effort to publish. However, the causal effect in this relationship may well run in the other direction. Furthermore, graduate students are not likely to publish as much as teaching-research faculty, and what publications they have may be the result of teaching-research faculty stimulation. A second criticism that can be leveled against both Finley and the current study is that membership lists may be incomplete for many departments, but the extent to which this is true would be very difficult to determine.

[3] Although it would also be desirable to make a separate accounting for those with primarily teaching duties or to take account of the percentage of faculty time devoted to teaching, sufficient data are not available in the *Handbook-Directory*.

[4] Publications by graduate students are not excluded from the revised results because there were few such publications, and

Table 1. Measures of Departmental Size Computed from the *Handbook-Directory*, 1972

University	AAEA Members	Teaching-Research AAEA Members	Primarily Extension AAEA Members	Graduate Students and Other AAEA Members
Arizona	42	17	2	23
California—Berkeley	42	14	3	25
California—Davis	46	26	0	20
Cornell	69	37	0	32
Florida	68	36	0	32
Illinois	82	46	2	34
Iowa State	81	40	1	40
Kansas State	42	23	0	19
Michigan State	114	45	2	67
Minnesota	82	35	2	45
Missouri	76	40	3	33
Montana State	24	20	0	4
North Carolina State	54	25	11	18
Ohio State	66	40	1	25
Oklahoma State	53	26	1	26
Oregon State	47	21	4	22
Pennsylvania State	45	32	1	12
Purdue	99	46	4	49
Texas A&M	47	27	3	17
Washington State	50	24	5	21
Wisconsin	66	29	1	36

determine (from the *Handbook-Directory*) the percentage of faculty time devoted to extension in departments where most faculty have split extension-teaching or extension-research appointments, published output per member is reported both with and without those listed as primarily involved in extension. The former may yield a better ranking, but the latter should be more indicative of research output by those expected to produce research (at least in departments that do not have split extension appointments). Inclusion or exclusion of extension, however, makes little difference in most of the rankings that result in table 2. Whether or not ex-

most such publications are done jointly with a faculty member. Also, faculty members are often responsible for generating the creative ideas that lead to graduate student publications.

Table 2. University Affiliation of Authors Contributing Papers to the *Journal*, 1968–72

University	Pages per Teaching-Research Faculty	Rank	Pages per Faculty Including Extension	Rank	Finley's Pages per Member	Rank	Total Pages	Rank
California—Berkeley	10.25	1	8.44	1	3.42	1	143.50	10
Oregon State	6.95	2	5.84	4	3.11	4	146.00	9
Wisconsin	6.84	3	6.61	2	3.00	5	198.25	4
California—Davis	6.00	4	6.00	3	3.39	2	156.00	7
North Carolina State	5.59	5	3.88	11	2.59	7	139.75	12
Purdue	5.15	6	4.74	7	2.39	9	237.00	1
Iowa State	5.06	7	4.94	5	2.50	8	202.50	3
Illinois	5.01	8	4.80	6	2.81	6	230.50	2
Pennsylvania State	4.84	9	4.34	8	3.18	3	143.25	11
Minnesota	4.39	10	4.15	9	1.87	13	153.50	8
Arizona	4.34	11	3.88	11	1.76	14	73.75	15
Missouri	4.14	12	3.85	13	2.18	10	165.50	6
Oklahoma State	4.08	13	3.93	10	2.00	11	106.00	14
Michigan State	4.00	14	3.83	14	1.58	15	180.00	5
Cornell	3.71	15	3.71	15	1.99	12	137.25	13
Kansas State	2.73	16	2.73	16	1.49	17	62.75	20
Washington State	2.73	16	2.26	18	1.31	18	65.50	19
Texas A&M	2.71	18	2.44	17	1.56	16	73.25	16
Florida	1.92	19	1.92	19	1.02	20	69.07	18
Ohio State	1.79	20	1.75	20	1.09	19	71.75	17

Table 3. University Affiliation of AAEA Members Contributing to Major Economic Journals, 1968–72

University	Pages per Teaching-Research Faculty	Rank	Pages per Faculty Including Extension	Rank	Pages per Member	Rank	Total Pages	Rank
California—Berkeley	4.48	1	3.69	1	1.49	1	62.66	1
Minnesota	1.16	2	1.09	2	0.49	3	40.50	2
California—Davis	0.88	3	0.88	3	0.53	2	22.80	3
Florida	0.46	4	0.46	4	0.24	4	16.50	4
Oklahoma State	0.35	5	0.33	5	0.17	5	9.00	7
Wisconsin	0.34	6	0.33	5	0.16	6	10.00	6
Purdue	0.26	7	0.24	7	0.12	8	12.00	5
Oregon State	0.26	7	0.22	9	0.12	8	5.50	12
Cornell	0.24	9	0.24	7	0.13	7	9.00	7
Iowa State	0.18	10	0.17	10	0.09	10	7.00	9
Michigan State	0.16	11	0.15	11	0.06	12	7.00	9
Illinois	0.13	12	0.12	12	0.07	11	5.83	11

tension is included, the University of California—Berkeley still ranks first, but the gap between first and second has widened considerably as compared with Finley's results. Also, the University of California—Davis has been displaced in second place by Oregon State University or the University of Wisconsin, depending on whether extension staff is included in departmental size. All four of the above departments, however, are in the top five by either Finley's rankings or the revised rankings of this paper.

The schools that change ranking the most (from Finley's ranking) are the University of Wisconsin, the University of Minnesota, and Pennsylvania State University. Pennsylvania State University fell from third to eighth or ninth, while the University of Wisconsin jumped from fifth to second or third. The University of Minnesota moved from thirteenth to ninth or tenth. The other notable change is that more separation exists between groups of schools than with Finley's results or the earlier Holland and Redman results. In each of the earlier studies, there were three or four clearly leading schools, but the rest of the top ten or twelve departments were not far behind.[5] In the revised results, however, the University of California—Berkeley is far in the lead at 8.44 or 10.25 pages per faculty member, and the next twelve or thirteen departments are in a group mostly between 4 and 6 pages per faculty member. In addition, the published output per member is not quite so dismal as Finley's calculations indicate; top-ranked Berkeley produced about one published *Journal* paper per faculty member in the five-year period.

The second objective of this note is to include significant agricultural economics research that is published in journals other than the *Journal*. Presumably, other refereed journal research of *Journal* quality or higher would be found mostly in well-known major economic journals, with wide circulation among the economics profession in general. A reasonable, but perhaps not exhaustive, list of such journals includes *American Economic Review, Econometrica, Journal of Political Economy, International Economic Review, The Economic Journal, The Quarterly Journal of Economics, The Review of Economics and Statistics, The Review of Economic Studies, Journal of the American Statistical Association, European Economic Review, Economica,* and *Journal of Economic Theory*.[6] Using these journals, the number of pages authored by AAEA members for the years 1968–72 was determined by using the 1972 *Handbook-Directory* (table 3).[7] Again, only those schools considered in the earlier studies by Holland and Redman and by Finley are included in table 3.[8]

[5] Only those schools considered in the earlier studies are included in table 2. On a per person basis, some schools not considered in the original study by Holland and Redman also become important. For example, the University of Chicago (which has few faculty AAEA members) would rank just behind the University of California—Berkeley in pages per faculty member with 9.13. Stanford University would rank just behind Cornell University with 3.28 and Montana State University behind Texas A&M University with 2.15.

[6] Of course, it would be interesting to consider all journals, particularly the regional agricultural economics journals. Such an exhaustive survey, however, would be very time consuming. This note is merely intended to include published research of at least the same quality as considered by the earlier surveys and admittedly is somewhat imperfect in accomplishing that objective. At least, the above list of journals should give a useful indication of the extent to which other outlets are used.

[7] Again, errors due to consideration of only those agricultural economists carrying AAEA membership must be considered. If a non-AAEA member of an agricultural economics department has written in the economic journals considered, that publication would not be considered. In the case of the University of California—Berkeley, for example, the complete total was 143.0 pages rather than 62.66, but the excess 80.34 pages could not be counted because the authors did not carry AAEA membership while in the University of California—Berkeley Department of Agricultural Economics. On the other hand, the pages of publication counted for a particular membership group more nearly pertain to that group than in Finley's and the *Journal* account in table 2. In the *Journal* account, inclusion of many *Journal* pages not authored by AAEA members could severely bias some of the pages-per-member estimates.

[8] One might question at this point why agricultural economics

As one can see, the results do not correspond closely to *Journal* output. Again, the University of California—Berkeley ranked first with nearly four times as much per teaching-research faculty member as any other department. The University of California—Davis also ranked high in publications in major economic journals, just as it did in the *Journal* publication. But the rest of the top five contributors to major economic journals ranked much lower by the earlier surveys considering only the *Journal*. Holland and Redman ranked the University of Minnesota eighth, the University of Florida eighteenth, and Oklahoma State University fourteenth. Finley ranked the University of Minnesota thirteenth, the University of Florida twentieth, and Oklahoma State University eleventh.

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research from, say, Harvard University and the University of Chicago, is not considered. Actually, when a similar accounting was attempted for other schools as well, it was found that the results were somewhat misleading. Many of the faculty from these schools are individuals who publish extensively but apparently do not carry a primary interest in agricultural economics.

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The Handbook of the American Farm Economics Association. J. Farm Econ. 48 (Nov. 1966), part 2.



Publications

Books Reviewed

Bender, Filmore E., Amihud Kramer, and Gerald Kahan. *Systems Analysis for the Food Industry.* Westport, Conn.: AVI Publishing Co., 1976, ix + 468 pp., $45.00, $23.00 softback.

The primary audience for this book are the professional systems analysts working with firms in the food industry, but firm managers and students will also be given useful insights into the application of operations research methods to problems in the food industry. The chapters cover a wide range of techniques that have application in the food industry, and most of the book is devoted to numerical illustrations of these techniques. The principal contribution of the book is to give the reader an understanding of possible applications of the techniques discussed. For this reason, it should be read by systems analysts in the food industry and can be used to supplement undergraduate courses dealing with operations research techniques.

There are three chapters on linear programming, one on integer programming, and one on the transportation problem. These techniques are more thoroughly developed than are others. One chapter is devoted to response surface techniques (regression analysis, analysis of variance, and evolutionary operations) and another to techniques for production control (assignment and sequencing problems using techniques from industrial engineering). The chapter on inventory control and budgeting presents some good applications for planning, where the firm faces various situations with respect to demand for its products. The chapter on breakeven analysis gives the reader a better idea about the versatility of that technique and potential applications than this reviewer has seen in other books. Applications of PERT (project evaluation and review technique) and CPM (critical path method) techniques to research and development management are illustrated. The authors correctly stress the importance of accurate sales forecasting and its relation to planning for other operations in the firm. Several techniques for sales forecasting are described (Delphi, regression analysis, exponential smoothing, and time series), but most of these are not developed to the point that the reader acquires the background to apply them to a problem. The chapter on game theory exposes the reader to the concepts involved but is otherwise not very useful. Given the emphasis on linear programming, it is disappointing that the author did not use it to show its application to the solution of games with mixed strategies.

This book is a survey of techniques applicable to solution of problems in the food industry, mainly in food processing. The level of math and statistics required to comprehend most of the content is quite low, consisting of algebra and a beginning course in statistics, although this varies among chapters. Calculus is used in a few parts. Each chapter starts with simple applications and proceeds to the more complex. The reader with little or no quantitative background can grasp and work through most of the material presented.

The principal shortcoming of the book is that it lays little theoretical or conceptual foundation for the techniques described or for the interpretation of results. The authors move directly into a technique with examples in a cookbook fashion. Further, some of the data problems and limitations of techniques are not adequately treated. For example, breakeven analysis starts with a statement of fixed and variable costs, with no mention of the fact that most cost items fall between these two extremes or suggestions about how to deal with such cases. The assumptions and limitations of breakeven analysis (and other techniques) are not adequately discussed. If decisions are based on results of techniques for which the limitations are not fully understood, this could give rise to some serious problems.

Emerson M. Babb
Purdue University

Donald, Gordon. *Credit for Small Farmers in Developing Countries.* Boulder, Col.: Westview Press, 1976, xi + 286 pp., $20.00.

Perhaps there has not been such a ubiquitous set of programs for small farmer development in the third world than those of agricultural credit. Some have met with considerable success; many have been disappointing in terms of effectively and efficiently delivering credit to small farmers through viable institutional structures. Donald properly concludes, "there is much to be learned about small farmer credit," (p. 271) and, "There is a great deal that can be done to improve the effectiveness of credit in rural development, both in the adoption of relatively familiar policies within the framework of national development strategies and in experimentation with less familiar policies" (p. 271).

Within this context this volume provides a unique opportunity for both the scholar and the practitioner to understand better the wide scope of issues, problems, and strategies involved in directing credit to the small farmer. The reason is the rich source of expertise and practical experience that the author has at his disposal in the more than sixty papers dealing with credit experience in specific less developed countries and the twenty analytical papers that together comprised the 1972–73 Agency

for International Development (AID) "Spring Review" on credit programs. This volume is the author's synthesis, analysis, and extension of the materials presented at the Review. Rarely does an author have the opportunity to draw upon such a sum total of recent experience and fresh thinking as is contained in these papers and, moreover, to participate in the intensive discussions among the practitioners and experts who attended the regional workshops and final conference that comprised the Review. The result is a volume that not only views the old, long recognized but still ever-present credit problems but also presents new perspectives and insights into the nature of the problems, as well as offering new alternatives for credit policy. Properly, Donald has concentrated on the broad analysis of problems and policy strategies. He very effectively, however, places them in the context of the real world by a measured interjection of the experiences in the individual countries.

The book is logically organized. After answering the question of "why small farmer credit?" in the introduction, the remaining four sections address the role of credit, financial institutions and policies, related institutions, and policies and strategies. A slight problem occurs as Donald, in an attempt to be loyal to the authors of the original papers, does not present a completely fused and unified piece but rather one that has some degree of fragmentation that could create a problem for the nonspecialist reader.

Although the present volume—as the Review—is underwritten by AID, it is far from being a forum to justify the AID credit program position. In fact, implicit criticism of that organization's credit program policy appears in the book along with suggested alternatives that are sometimes inimical to contemporary AID policy. An example is the criticism of a standard AID credit component—the concessionary interest rate. Donald properly puts this into the context of the overall rural financial market and demonstrates how this policy works against lender profitability, tends to direct credit to larger farmers, and discourages rural savings and hence institutional capital formation. Yet, he also stresses that, since this policy is a powerful political weapon to gain small farmer favor, and given that it is widely employed, even if government leaders and policy makers could be convinced of the desirability of raising interest rates it would be very difficult to convince them that they should in fact do so.

Donald clearly leaves the reader with the sobering impression that credit programs are not the simple route to rural development as they were once imagined. Thus, he does not argue for a canned credit program strategy that can be readily transferred from country to country around the world. Rather, he argues that credit programs must be carefully tailor-made to the specific needs and conditions of a particular country or even regions within a country. Their success in part depends upon how they properly mesh with the culture of the lender and borrower and the presence of complementary programs of marketing, education, and farmer organizations. Moreover, it must be recognized that there are inherent conflicts within programs; they cannot simultaneously be expected to be low cost, have low default rates, increase production, and improve rural income distribution. Donald also suggests that more study be made of the informal market. Much can be learned from these lenders. Although interest rates are often high, these lenders offer the farmer opportune credit with an amazing degree of efficiency.

In conclusion, this volume represents a significant contribution to the credit literature because it has brought together under one cover in a readily accessible and diffusible form a balanced view of the current state of thinking about small farmer credit problems, programs, and strategies. As such, it should be a basic reference for not only the scholar but also the practitioner who is involved in designing credit programs and policy.

Jerry R. Ladman
Arizona State University

Fallenbuchl, Zbigniew M., ed. *Economic Development in the Soviet Union and Eastern Europe, Volume 2: Sectoral Analysis*. New York, Washington, London: Praeger Publishers, 1976, 412 + xvii pp., $27.50.

Volume 2 is said to be the third of an eight-volume set of selected papers to be published out of a total of 250 that were presented at the First International Slavic Conference in Banff, Alberta, Canada, 4–7 September 1974. Papers included in volume 2 are divided into three parts: part I, industry and foreign trade, including six papers plus comments; part II, agriculture, with seven papers, and part III, conflict in the public sector, with three papers and an introduction. Thus, the volume represents a rather heterogeneous collection of topics whose common denominator is economic development in a territory inhabited by mostly Slavic peoples and now largely under Communist rule.

The readers of this *Journal* are most likely interested in part II, agriculture. Consequently, this review focuses essentially on that part of the book, which represents a little over one-third of the total pages. The seven authors include internationally known specialists in Soviet agriculture, whose papers are essentially empirical analyses or historical reviews.

Keith Bush (Radio Liberty, Munich, Germany) in the longest and thoroughly researched lead paper of part II presents a detailed and comprehensive account of the last ten years of Soviet agriculture under the Brezhnev-Kosygin management. "Official Soviet data are utilized, despite their known

shortcomings," (p. 157) to construct a mosaic picture of inputs, supplies, policy and organizational measures, and the output levels attained. In author's summary assessment, the period represents "a consistent policy consistently implemented" (p. 157), characterized by vigorous intensification efforts in farm production to secure self-sufficiency in staple foodstuffs and in agricultural raw materials. Also, new management has sought to "correct a third of the century's exploitation and neglect of the farm sector with a massive transfer of resources from the rest of the economy" (p. 157).

Yet, as the author correctly points out, the achievements must be considered incommensurately modest due partly to unfavorable climate "but also in large part to continuing penchant for the overcentralization of decision-making and for gigantic production units, to an ideological bias against the farmer" (p. 158).

In scope, detail, and depth (196 footnote references), Bush's forty-eight-page contribution is easily the backbone of part II and of the book. It is refreshingly informative and updates developments until the year 1974. One detail in particular catches the eye because it is rarely discussed in Soviet and western publications. It concerns agricultural subsidies and the total support bill in the Soviet Union, about which very little is known, yet which happens to be the largest in the world (p. 173). Bush puts its magnitude in a glaring perspective by the following figures. The best western estimates calculated the subsidies for 1974 at some 16 billion rubles, compared to the overt Soviet defense appropriation of 17.6 billion rubles. The subsidy bill is "equivalent to over 25 percent of the national income originating in agriculture, and it is equal to about five percent of the national income (Soviet concept)" (p. 174).

The paper also shows how hazardous it is to predict in Soviet agriculture. The author thought in 1974 "that the output levels attained in the period 1971–75 will come credibly close to meeting the targets" (p. 162). The calamitous crop failure in 1975 frustrated that prediction. Although the 1971–75 overall achievement was better than the previous 1966–70 five-year period, it fell short of the 20% to 22% growth target. The judicious assessment that "the meat product targets for 1975 look unrealistically high" (p. 180) proved ironically wrong, too, because of the extra heavy slaughterings due to crop failure. Meat shortages were being felt in 1976, while in late 1975 meat supply was abundant.

In other papers, Arkadus Kahan (University of Chicago) deals with the problem of the Soviet "agrarian-industrial complexes," as yet a poorly defined and hazy concept and goal. However, it is widely discussed in connection with the grand resettlement plans for rural population into agrotowns. David M. Schoonover's (U.S. Department of Agriculture) paper outlines projections and policies of the Soviet feed-livestock economy, where the Soviets face a choice between limiting the growth of demand for livestock products and importing needed feed grain. Roy D. Laird (University of Kansas) considers Soviet farmer productivity in 1950–70 as measured by a U.S. barometer. He attempts to quantify the well-known large differences between the Soviet Union and the United States and to show the comparative advances over two decades in terms of grain per farmer, crop yields, and production per capita and per farmer. Alec Nove (University of Glasgow) continues the comparative theme with a paper on "Agricultural Performance Compared: Belorussia and Eastern Poland." It is an interesting attempt to juxtapose the performance of collectivized and peasant agriculture under nearly similar conditions, both relatively backward regions in their respective countries.

Everett M. Jacobs's (University of Sheffield) paper on the organization and management of agriculture in eastern Europe, 1967–74, reviews the reforms and new directions that have been so prominent over the last decade. A related paper by Lewis A. Fisher (McGill University) explores the efficiency in Hungarian agriculture after six years of economic reforms, which concludes part II of the book.

All the papers in part II are expertly written and informative, exploring new aspects and updating information up to 1974. The same can be said about the rest of the volume that could not be discussed here. The book is a valuable contribution to the knowledge in development problems in centrally planned command economies. It can be highly recommended to those interested in, or working on, the Soviet or East European problems.

Elmar Jarvesoo
University of Massachusetts, Amherst

Yotopoulos, Panos A., and Jeffrey B. Nugent. *Economics of Development—Empirical Investigations*. New York: Harper & Row, Publishers, 1976, xxiii + 478 pp., price unknown.

The launching pad for this book is a rude attack on the existing body of literature on development economics. In a search for how-to-do-it recipes, development economists have proliferated a variety of dogmas and abstract theories that have rarely been corroborated by hard empirical evidence. Furthermore, development economics has been enslaved to the neoclassical paradigm with its emphasis on smooth, continuous, and self-equilibrating growth processes. This enslavement results in total failure to predict the chronic problems of

unemployment and inequality that are so rampant in the developing world today.

The spirit of the book is of a science-to-the-rescue operation. By sifting out those theories and hypotheses that have, or can be, empirically tested and verified, it is hoped to provide the building blocks for an eventual general theory of economic development. Special features of the rescue operation are an eclectic approach to avoid the pitfalls of dogma and fundamentalism and the consideration of models of structural disequilibria to account for such phenomena as chronic unemployment and poverty.

After a brief review of the method of scientific investigation, a number of historical and socioeconomic theories of development are quickly dismissed (e.g., Rostow and Adelman and Morris) as being inoperational in terms of empirical testing. The book then proceeds to a lengthy review of many bits and pieces of neoclassical analysis. Herein is to be found a solid treatment of the microeconomics of production and especially of the definition and measurement of economic efficiency in resource use. The latter suffers somewhat from an excessive concentration on single-product models for statistical testing. A growing literature on allocative behavior as studied through mathematical programming models has been totally ignored, despite its richer behavioral and technical content. One can only be awed, too, by the esoteric derivation of an index of economic rationality (pp. 88–92 and chapter appendix) that collapses to the essential proposition that firms operating on Cobb-Douglas production functions differing only by a constant term will combine their inputs in directly proportional ways.

The book proceeds to a discussion of the efficiency costs of monopoly and trade distortions, suggesting that these costs may have been underestimated in the past because of the limitations of partial equilibrium analysis. A section on dynamics then provides a useful review of such topics as adaptive learning behavior in supply response models, the sources and measurement of technological change, models of savings behavior, and human capital theory.

The book reverts to a key theme that economic development involves structural shifts and changes and that growth is a process of successive disequilibria rather than of smooth, neoclassical change. Some evidence on migration and urban-rural wage differentials is then mustered to challenge the validity of the neoclassical paradigm that predicts that migration acts to equalize earnings. A rather unsatisfactory review follows of some economic models that possibly explain continued rural-urban migration despite prevalent urban unemployment. Likewise, a chapter on income distribution, poverty, and dualism follows, which, while highlighting the shortcomings of the neoclassical paradigm, fails to provide anything very useful in the way of disequilibria hypotheses. There is a useful review of alternative measures of income distribution and of some statistical analysis that relates various socioeconomic variables to income inequality, but little is offered in the way of a theory of poverty.

This rather vacuous treatment of development disequilibria fizzles out with a covert return to equilibrium analysis. There follow review chapters on the interactions between agriculture and nonagriculture, on the sectoral composition of growth (including a discussion of balanced versus unbalanced growth), and on the advantages and disadvantages of trade and economic integration. The usual tools of input-output models and partial equilibrium analysis figure prominently in these discussions.

Finally, under the heading of development disquilibrium—planning, there is a review of project appraisal techniques and a rather dated introduction to macroeconomic planning models for consistency evaluation and normative planning.

The authors are right to stress the need for a theory of development disequilibria. This, of course, is not entirely a new departure—witness the large Marxian literature on the subject. The problem faced by the authors is that they have set up stringent standards for empirical verification of any hypothesis that they are willing to accept, and existing theories on development disequilibria simply cannot be reduced to neat mathematical propositions for statistical evaluation. One admires the authors' belief that development economics should, and can, be reduced to an exact science. However, if the content of this book is any indication of the likely content of that science, then this reader for one has grave doubts about its value in contributing to the mastering of the diverse political, historical, social, and economic forces that impinge upon the development process.

The book is not without its merits, however. It is a useful review of many diverse topics in applied econometrics that have relevance to development economics. As such, it should prove useful to graduate students, teachers, and researchers alike. The treatment is largely mathematical; despite claims to the contrary, the book will probably be of little value to readers without a good quantitative training.

Regrettably, the style of the book is often pretentious and irritating. In exaggerating the authors' own contributions to the literature, the book loses much in the way of a balanced review. There is also a generous share of errors and model misspecifications for those who care to work through the algebra. For example, the proposed statistical estimation of the matrix BB^{-1} $(= I)$ on page 33 can only be described as quaint, whereas the definition of the ijth element of $(I - A)^{-1}$ as $1/(1 - a_{ij})$ on page 267 is

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Sacharow, Stanley. *Handbook of Package Materials*. Westport, Conn.: AVI Publishing Co., 1976, xi + 243 pp., $22.00.

Spencer, Dunstan S. C., Ibi L. May-Parker, and Frank S. Rose. *Employment, Efficiency and Income in the Rice Processing Industry of Sierra Leone*. African Rural Econ. Pap. No. 15, Dep. Agr. Econ., Michigan State University, 1976, ix + 78 pp., price unknown.

Sultan, William J. *Practical Baking*. Westport, Conn.: AVI Publishing Co., 1976, xvii + 599 pp., price unknown.

———. *Practical Baking Manual*. Westport, Conn.: AVI Publishing Co., 1976, viii + 175 pp., price unknown.

Thompson, Bruce. *Black Walnut for Profit: A Guide*

to Risk and Rewards. Scottsdale, Ariz.: Walnut Press, 1976, ix + 285 pp., $9.95, $7.95 paper.

Tweeten, Luther, and George L. Brinkman. *Micropolitan Development: Theory and Practice of Greater Rural Economic Development*. Ames: Iowa State University Press, 1976, ix + 456 pp., $20.00.

Walters, David. *Futures for Physical Distribution in the Food Industry*. Lexington, Mass.: Lexington Books, D.C. Heath & Co., 1976, viii + 156 pp., $14.50.

Announcements

Annual Meeting, 1977

The annual meeting of the American Agricultural Economics Association will be held jointly with the Western Agricultural Economics Association at the Town and Country Motel, San Diego, California, 31 July–3 August. Inquiries should be directed to Kenneth R. Farrell, President, AAEA, or William E. Martin, President, WAEA.

Editor-Elect

Starting with the February 1978 issue, V. James Rhodes will be the editor and S. R. Johnson the associate editor of this *Journal*. An announcement about the Book Review Editor will be made in the August issue. Starting 27 June, new submissions of manuscripts should be sent to V. James Rhodes, Department of Agricultural Economics, 200 Mumford Hall, University of Missouri, Columbia, Missouri 65201. Revisions of prior submissions should be sent to the current editor at Cornell so that the entire folder may be forwarded to the new editor.

NACTA Meets

The National Association of Colleges and Teachers of Agriculture will hold its annual conference 13–15 June 1977. The meeting will be held on the campus of The Pennsylvania State University at University Park. The theme of this year's conference is "Effective Teaching in Agriculture: By All Means." For information on this meeting, write to Robert E. Swope, 217 Agricultural Administration Building, University Park, Pennsylvania 16802.

Employment Service

Employment services will be provided at the AAEA annual meeting in San Diego, 31 July to 3 August 1977. These services are an extension of the year-round service provided by the AAEA's Registry for Agricultural Economists. Since the Registry provides year-round service, persons should register as soon as they become available for a job assignment, whether for a temporary or a long-term assignment. As previously announced, those persons who intend to use the employment service at the San Diego meeting and who wish to have their resumes sent to employers prior to the meeting should be registered by 1 June 1977. Employers who wish to receive resumes prior to the meeting should have their job vacancies listed by 1 July 1977. Registration forms may be obtained from the Registry for Agricultural Economists, Illinois State Employment Service, 40 West Adams Street, Chicago, Illinois 60603; telephone: 312-793-4903.

AAEA Committee Structure, 1976–77

Ad Hoc Committees

AJAE Page Charge

Lee M. Day, Chairman, Cornell University
Neil E. Harl, Iowa State University
V. James Rhodes, University of Missouri
William G. Tomek, Cornell University

Edward W. Browning Award Nominations

A. Gordon Ball, Chairman, University of Guelph
Irving Dubov, University of Tennessee
Jerry B. Eckert, Colorado State University
Vernon R. Eidman, University of Minnesota
Terry F. Glover, Utah State University
Dale J. Menkhaus, University of Wyoming
Everett E. Peterson, University of Nebraska
Richard W. Schermerhorn, University of Idaho

Special Committees

Alternative Publications

Verner G. Hurt, Chairman, Mississippi State University, 1975
Harold F. Breimyer, University of Missouri, 1975
Ben C. French, University of California, Davis, 1975
Glenn E. Heitz, Federal Land Bank of St. Louis, 1976
Fred A. Mangum, North Carolina State University, 1976 (Board Rep.—one-year term)
Paul E. Nelson, Economic Research Service, USDA, 1975
James M. Nielson, Washington State University, 1976
Stephen C. Smith, University of Wisconsin, 1975
Glen V. Vollmar, University of Nebraska, 1975

Business Organization and Management (to be appointed)

Contributed Papers

Odell L. Walker, Chairman, Oklahoma State University, 1976
Daniel D. Badger, Cochairman, Oklahoma State University, 1976 (one-year term)
Harry P. Mapp, Cochairman, Oklahoma State University, 1976 (one-year term)
Chauncey T. Ching, University of Nevada, 1976
Martin K. Christiansen, University of Minnesota, 1976 (two-year term)
Milton C. Hallberg, Pennsylvania State University, 1976 (two-year term)
James A. Niles, University of Florida, 1976
Martin T. Redfern, University of Arkansas, 1976 (two-year term)
T. Kelley White, Purdue University, 1976
Eldon E. Weeks, Economic Research Service, USDA, 1976 (one-year term)

Employment Services

Loys L. Mather, Chairman, University of Kentucky, 1970
David M. Bell, Connell Commodities, 1976
Raymond R. Beneke, Iowa State University
G. T. Dowdy, Tuskegee Institute, 1974
Stephen B. Harsh, Michigan State University, 1973
Dale E. Hathaway, International Food Policy Research Institute, 1971
Melvin R. Janssen, Economic Research Service, USDA, 1970
Paul L. Kelley, Kansas State University, 1976

Evaluation of Annual Meeting

Henry J. Meenen, Chairman, University of Arkansas, 1975
Wallace Barr, Ohio State University, 1976 (Board Rep.—one-year term)
Charles L. Beer, Extension Service, USDA, 1975
Joseph D. Coffey, Virginia Polytechnic Institute and State University, 1975
Otto J. Doering, Purdue University, 1975
Richard T. Herder, Central Soya, 1975
John G. McNeely, Texas A&M University, 1975
Kenneth C. Nobe, Colorado State University, 1975
Lawrence W. Witt, U.S. Department of State, 1975

Extension Affairs

Robert L. Christensen, Chairman, University of Massachusetts, 1975
Norbert Dorow, North Dakota State University, 1975
W. S. Farris, Purdue University, 1975
Fred A. Mangum, North Carolina State University, 1976 (Board Rep.—one-year term)
Gene Nelson, Oregon State University, 1975
Bobby H. Robinson, Clemson University, 1975
Charles H. Rust, Montana State University, 1974
William W. Wood, University of California, Riverside, 1976
W. Fred Woods, Extension Service, USDA, 1976

Handbook-Directory

Howard F. Robinson, Chairman, North Carolina A&T State University, 1974

Emanuel O. Melichar, Federal Reserve Bank System, 1974
John C. Redman, University of Kentucky, 1974

Industry Affairs

Eugene E. Gerke, Chairman, Supermarket Institute, 1974
Donald E. Ault, Land-O-Lakes, 1976
Paul A. Baumgart, Safeway Stores, Inc., 1974
Richard A. Benson, Caterpillar Tractor, 1976
Richard T. Crowder, Pillsbury Co., 1976 (Board Rep.—one-year term)
Charles E. Erickson, Cargill, Inc., 1974
John A. Knechel, Bank of America, 1976
Walter M. Myers, Connell Rice and Sugar Co., 1975
Bruce A. Scherr, Data Resources, Inc., 1975
Arthur G. Wilson, Canada Grains Council, 1974

International

Harold M. Riley, Chairman, Michigan State University, 1975
Ralph W. Cummings, Jr., International Agricultural Development Service, 1976
Charles E. Hanrahan, Economic Research Service, USDA, 1976
William C. Merrill, Agency for International Development, 1975
Kenneth C. Nobe, Colorado State University, 1976
Philip M. Raup, University of Minnesota, 1976 (Board Rep.—one-year term)
C. Peter Timmer, Cornell University, 1974
Francis Van Gigch, World Bank, 1976
Abraham M. Weisblat, Agricultural Development Council, 1973

Literature Retrieval

Wayne D. Rasmussen, Chairman, Economic Research Service, USDA, 1976
Hilarius W. Fuchs, Continental Grain, 1976
James R. Gray, New Mexico State University, 1976
Philip L. Martin, University of California, Davis, 1976
Elmer L. Menzies, University of Guelph, 1976
Robert E. Olson, South Dakota State University, 1976
Rudie W. Slaughter, University of Missouri, Economic Research Service, USDA, 1976
Cecil N. Smith, University of Florida, 1976
Raymond C. Smith, University of Delaware, 1974
Harry C. Trelogan, Arlington, Virginia, 1976

Nominating

James T. Bonnen, Chairman, Michigan State University
B. R. Eddleman, Mississippi State University
Glenn E. Heitz, Federal Land Bank
Darrell L. Hueth, University of Rhode Island
Richard J. McConnen, Montana State University
William T. Manley, Agricultural Marketing Service, USDA
W. Neill Schaller, Farm Foundation
J. B. Wyckoff, Oregon State University
(All one-year terms)

Professional Registries

David H. Boyne, Chairman, Ohio State University, 1975
Raymond R. Beneke, Iowa State University, 1975
Orville Bentley, University of Illinois, 1975
Richard T. Crowder, Pillsbury Co., 1976 (Board Rep.—one-year term)
Allan S. Johnson, Economic Research Service, USDA, 1976
Richard J. McConnen, Montana State University, 1975
James S. Plaxico, Oklahoma State University, 1975
Leo Polopolus, University of Florida, 1975

Publication of Postwar Literature Review

Emerson M. Babb, Chairman, Purdue University, 1974
J. Patrick Madden, Pennsylvania State University, 1974
Lee R. Martin, University of Minnesota, 1974
John C. Redman, University of Kentucky, 1974

Review of Fellows Selection Process

Harry C. Trelogan, Chairman, Arlington, Va., 1975
George Brandow, Pennsylvania State University, 1975
Emery N. Castle, Resources for the Future, 1975
John O. Dunbar, Kansas State University, 1975
William D. Toussaint, North Carolina State University, 1975

Visiting Lecturer

William Herr, Chairman, Southern Illinois University, 1973
Willard W. Cochrane, University of Minnesota, 1975
Leroy Davis, Southern A&M University, 1976
R. Vern Elefson, University of Wisconsin—River Falls, 1975
Wayne D. Purcell, Oklahoma State University, 1975
W. Neill Schaller, Farm Foundation, 1975
John Sjo, Kansas State University, 1975

Standing Committees

Audit

James E. Crisswell, Chairman, University of Kentucky, 1970
Larry D. Jones, University of Kentucky, 1974

Awards

A. Gordon Ball, General Chairman, University of Guelph

Distinguished extension programs
Everett Peterson, Chairman, University of Nebraska, 1974
Robert J. Bevins, University of Missouri, 1975
H. Doss Brodnax, Mississippi State University, 1974
Charles W. Coale, Virginia Polytechnic Institute and State University, 1975
George A. Ecker, University of Connecticut, 1974
Wayne A. Hayenga, Texas A&M University, 1976
Verne W. House, Montana State University, 1974
Ray Prigge, University of Idaho, 1975
Paul R. Robbins, Purdue University, 1976

Distinguished undergraduate teaching
Richard W. Schermerhorn, Chairman, University of Idaho, 1974
Maurice J. Danner, Auburn University, 1975
Donald B. Erickson, Kansas State University, 1976
John D. Helmberger, University of Minnesota, 1976
Billy V. Lessley, University of Maryland, 1974
Paul E. Nesselroad, West Virginia University, 1976
James E. Osburn, Texas Tech University, 1975
Kenneth C. Schneeberger, University of Missouri, 1975

Outstanding doctoral program
Terry Glover, Chairman, Utah State University, 1975
Dale G. Anderson, University of Nebraska, 1976
Harry W. Ayer, University of Arizona, 1975
Dale C. Dahl, University of Minnesota, 1975
Walter Haessel, Pennsylvania State University, 1976
Dale M. Hoover, North Carolina State University, 1976
Ed F. Jansen, University of New Hampshire, 1975
Richard Just, University of California, Berkeley, 1976
Abbas Mirakhor, University of Alabama, Huntsville, 1974
Gordon C. Rausser, Harvard University, 1974
C. Richard Shumway, Texas A&M University, 1974
Melvin D. Skold, Colorado State University, Economic Research Service, USDA, 1976
Ronald W. Ward, University of Florida, 1976

Outstanding master's programs
Dale J. Menkhaus, Chairman, University of Wyoming, 1974
Thomas Carlin, Economic Research Service, USDA, 1975
Thomas Daves, South Dakota State University, 1975
Olan D. Forker, Cornell University, 1975
William D. Gorman, New Mexico State University, 1974
F. Richard King, University of Maine, 1976
Larry J. Martin, University of Guelph, 1976
Glenn Nelson, Purdue University, 1975
Anne Peck, Food Research Institute, Stanford University, 1976
J. B. Penn, Economic Research Service, USDA, 1974
Travis D. Phillips, Mississippi State University, 1974
Robert N. Shulstad, University of Arkansas, 1974
Heinz Spielmann, University of Hawaii, Economic Research Service, USDA, 1974

Publications, quality of communication
Irving Dubov, Chairman, University of Tennessee, 1976
W. G. Aanderud, South Dakota State University, 1975
Kenneth D. Duft, Washington State University, 1976
Harold P. Guither, University of Illinois, 1976
Sidney Ishee, University of Maryland, 1975
David E. Kenyon, Virginia Polytechnic Institute and State University, 1976
William E. Martin, University of Arizona, 1976
James L. Pearson, Economic Research Service, USDA, 1976
Norman Townshend-Zellner, California State College, Fullerton, 1976

Publications, quality of research discovery
Irving Dubov, Chairman, University of Tennessee, 1975
John Brake, Michigan State University, 1976
Bruce W. Cone, Battelle Northwest, 1974
Clark Edwards, Economic Research Service, USDA, 1975
Bruce Gardner, Council of Economic Advisers, 1976
James B. Hassler, University of Nebraska, 1976
James F. Hudson, Louisiana State University, 1976
Andrew Schmitz, University of California, Berkeley, 1976
Cleve E. Willis, University of Massachusetts, 1975

Publications of enduring quality
Vernon R. Eidman, Chairman, University of Minnesota, 1973
George J. Conneman, Jr., Cornell University, 1976
Gerald A. Doeksen, Oklahoma State University, Economic Research Service, USDA, 1976
A. H. Harrington, Washington State University, 1975
Joseph C. Headley, University of Missouri, 1976
Neil R. Martin, University of Georgia, Economic Research Service, USDA, 1975
Alan Randall, University of Kentucky, 1974
Stanley K. Seaver, University of Connecticut, 1976
Stephen H. Sosnick, University of California, Davis, 1975

Economic Statistics

Luther G. Tweeten, Chairman, Oklahoma State University, 1974
Arlo W. Biere, Kansas State University, 1976
W. Keith Bryant, Cornell University, 1974
Norman M. Coats, Ralston Purina Co., 1975
Howard W. Hjort, Schnittker Associates, 1976
William E. Kibler, Statistical Reporting Service, USDA, 1976
Norman K. Whittlesey, Washington State University, 1976
Gaylord E. Worden, Economic Research Service, USDA, 1974

Fellows Election

Lauren K. Soth, Chairman, Des Moines Register and Tribune, 1973
Emery N. Castle, Resources for the Future, 1976
Karl A. Fox, Iowa State University, 1972
Vernon W. Ruttan, Agricultural Development Council, 1974
Holbrook Working, Stanford University, 1975
James T. Bonnen, Michigan State University, 1976 (Board Rep.—one-year term)

Finance

B. F. Stanton, Chairman, Cornell University, 1974
Wallace Barr, Ohio State University, 1975
Peter J. Barry, Texas A&M University, 1975
Michael D. Boehlje, Iowa State University, 1975
John C. Redman, University of Kentucky, 1974

Membership

John E. Lee, Chairman, Economic Research Service, USDA, 1972
Thomas G. Brown, University of Missouri, 1975 (SAEA Rep.)
David Y. Chen, North Carolina A&T State University, 1974
Thomas S. Clevenger, New Mexico State University, 1976 (WAEA Rep.)
John E. Cottingham, University of Wisconsin—Platteville, 1975
Charles E. Erickson, Cargill, Inc., 1976 (one-year term)
Thomas L. Frey, University of Illinois, 1975
John D. Graham, University of British Columbia, 1975
Reed Hertford, Ford Foundation, 1976
Sylvia Lane, University of California, Davis, 1976 (Board Rep.—one-year term)
Theodore F. Moriak, Office of Management and Finance, USDA, 1976
Donald G. Stitts, University of Connecticut, 1976 (NAEC Rep.)

Professional Activities

Paul W. Barkley, Chairman, Washington State University, 1976
Donald R. Levi, Texas A&M University, 1975
Larry W. Libby, Michigan State University, 1975
Kenneth D. McIntosh, West Virginia University, 1975
J. Paxton Marshall, Virginia Polytechnic Institute and State University, 1975
Philip M. Raup, University of Minnesota, 1975 (Board Rep.)
Bernard L. Sanders, Farmland Industries, 1975
Bruce A. Scherr, Data Resources, Inc., 1976 (three-year term)
Gene L. Wunderlich, Economic Research Service, USDA, 1975

Resident Instruction

Glenn C. Himes, Chairman, Ohio State University, 1974
J. Larry Johnson, University of Georgia, 1975 (Undergraduate Rep.)
A. Robert Koch, Rutgers University, 1975
Marvin W. Kottke, University of Connecticut, 1976
Hong Y. Lee, Texas Tech University, 1975
Carl W. O'Connor, Oregon State University, 1976
Milton M. Snodgrass, New Mexico State University, 1975
Walter J. Wills, Southern Illinois University, 1974

Tellers Committee

Harry H. Hall, Chairman, University of Kentucky, 1973
Lynn W. Robbins, University of Kentucky, 1976

Other Committees

USDA Joint Advisory Committee on Agricultural Statistics (AAEA and ASA)

Norman M. Coats, Ralston Purina Co., 1976
James D. Houck, University of Minnesota, 1976
Luther G. Tweeten, Oklahoma State University, 1976
(All two-year terms)

Liaison Representatives

Representative to the Agricultural Development Council and Research and Training Network

C. Peter Timmer, Cornell University, 1974 (three-year term)

Representative to the American Society of Agronomy

Jerry B. Eckert, Colorado State University, 1976 (three-year term)

Representative to the Bureau of Census Advisory Committee on Agricultural Statistics

M. L. Upchurch, University of Florida, 1975 (three-year term)

Representative to the Federal Statistics Users Conference

Norman M. Coats, Ralston Purina Co., 1975 (three-year term)

Representative to the National Bureau of Economic Research

G. Edward Schuh, Purdue University, 1976 (three-year term)

Representative to the National Research Council

John C. Redman, University of Kentucky

U.S. Council of the International Association of Agricultural Economists, 1976–79

Norman R. Collins, Ford Foundation
Allen B. Paul, Economic Research Service, USDA
Lyle P. Schertz, Economic Research Service, USDA
J. B. Wyckoff, Oregon State University

Personnel

Agricultural Development Council

Retirement: Arthur T. Mosher, former associate in Sri Lanka, is in Ithaca, New York.

University of Arizona

Appointment: Marilyn A. Altobello, formerly with the ERS, USDA, is an assistant professor.

Cornell University

Appointments: Kenneth V. Gardner, senior extension associate, is an extension land use specialist; **William King,** formerly at Purdue University, is a research support specialist in land economics and regional agricultural studies; **Michio Sugiyama,** professor, Gifu University, Japan, is a visiting fellow.
Honors: Howard E. Conklin, professor, and **Robert S. Smith,** professor of farm finance, received special citations from the New York State Association of County Agricultural Agents.

University of Florida

Appointments: Bennett Abbitt, assistant professor, is an area farm management economist at the Area Resource Economics Center, Lake Alfred; **Roy R. Carriker,** Ph.D. Virginia Polytechnic Institute and State University, and **Richard L. Kilmer,** formerly with the USDA, are assistant professors; **John R. Gordon,** formerly at Purdue University, is an associate professor; **Richard C. Hooks** is an assistant.
Leaves: Max R. Langham remains on leave with the Agricultural Development Council, Singapore, for one more year through 1977; **Cecil N. Smith** is on leave with the Development Planning and Research Associates of Manhattan, Kansas, for six months beginning 26 Jan. 1977.

University of Guelph

Appointments: Thomas F. Funk is on the Board of Directors of the Canadian Agrimarketing Association for two years; **Larry Martin** is on the Board of Governors of the Winnipeg Commodity Exchange for one year.

CED: Commodity Economics Division of the Economic Research Service; EDD: Economic Development Division of ERS; FDCD: Foreign Demand and Competition Division of ERS; NEAD: National Economic Analysis Division of ERS; NRED: Natural Resource Economics Division of ERS.

University of Illinois

Leave: Takashi Takayama is a visiting professor, University of Florida.

Louisiana State University

Appointment: Wayne M. Gauthier, Ph.D. Oklahoma State University, is an assistant professor for three years under PL 89-106 grant funds.

University of Maryland

Appointments: Allen M. Prindle, Ph.D. The Pennsylvania State University, is an assistant professor in agricultural policy; **Ivar Strand,** former assistant professor, College of William and Mary, is an assistant professor in marine resource economics.

University of Massachusetts

Leave: Bradford D. Crossmon, professor of food and resource economics, is a visiting professor, University of Arizona, for six months.

Michigan State University

Appointment: Herbert Kreisel, professor, is in Korea on an MSU project.
Returns: Kelly Harrison is back from Colombia; **Garland Wood** is back from Pakistan.

University of Minnesota

Appointments: P. C. Goswami, professor and head, Department of Agricultural Economics, Assam Agricultural University, Jorhat, India, is a visiting professor, 1 Jan.–30 June; **Jean L. Kinsey,** Ph.D. University of California, Davis, is an assistant professor in consumption-consumer economics; **Glenn L. Nelson,** formerly at Purdue University, is in the Department of Agriculture and Applied Economics.
Leaves: John D. Helmberger, professor, is on leave with Tamil Nadu Agricultural University, Coimbatore, India, 20 Dec.–1 Apr.; **Robert W. Snyder,** associate professor and extension land economist, is on sabbatical leave at the William Mitchell College of Law, 16 Nov. 1976–15 May 1977.

University of Missouri

Appointments: Patrick Cantlon, Ph.D. University of Wisconsin—Madison, is an assistant professor in extension marketing; **David E. Ervin,** Ph.D. Oregon State University, is an assistant professor in natural resources.

Ohio State University

Returns: Richard D. Duvick, associate professor, is back after two years in Korea with a cooperative project concerned with Korean agricultural policy; **Thomas T. Stout,** professor, is back after four months as a visiting professor, University of Alberta, Canada.

Pennsylvania State University

Leave: Milton C. Hallberg is a visiting professor, Oklahoma State University, through June 1977.
Retirement: George E. Brandow, former professor of agricultural policy, after 37 years of service.

Purdue University

Appointments: David A. Bessler, Jon A. Brandt, Stephen P. Erickson, Marshall A. Martin, and **Wallace E. Tyner** are assistant professors.
Leave: Otto C. Doering, Jr., is on leave with the Agricultural Policy Analysis Program Area, CED, ERS, USDA.
Resignations: Donald A. Hilger is in the Economic Analysis Department, Cargill, Inc., Minneapolis, Minnesota; **Lennis D. Mitchell** is with Fairmont Food Company, St. Louis Park, Minnesota; **William F. Newell** is an agricultural economist with the Inter-State Milk Producers, Southampton, Pennsylvania; **Robert J. Rades** is with Snyder Associate Inc., Consultants, West Lafayette, Indiana.
Honors: Otto C. Doering, Jr., received the Junior Award for an extension specialist; **Eric C. Oesterle** received the USDA tenure award for 30 years extension service to Indiana; **G. Edward Schuh** is a member and the director of the National Bureau of Economic Research.

Rutgers—The State University

Appointments: Roger Beck, Ph.D. Pennsylvania State University, is an assistant professor in environmental and business economics; **Michael Varner,** Ph.D. Cornell University, is an assistant professor in marketing research.
Resignation: Farrell E. Jensen is the director of marketing, Food Machinery Corporation.

Honor: Daymon W. Thatch received the 1976–77 Distinguished Member Award from the Northeast Agricultural Economics Council.

Texas A&M University

Appointment: Peter J. Barry, associate professor, is the editor of the *Western Agricultural Economics Journal,* 1976–79.

Texas Tech University

Appointment: Bob Davis, former associate professor, University of Houston, is an associate professor.

U.S. Department of Agriculture

Appointment: Harry Ayer, former associate professor, University of Arizona, is with the Resource Program Studies staff, NRED, Tucson, Arizona.
Appointments in CED: James D. Johnson, Ronald L. Meekhof, and **Ronald R. Miller** are with the Agricultural Policy Analysis Program Area; **R. McFall Lamm** is with the Oil Crops Program Area, Blacksburg, Virginia; **Patrick Moast** is with the Dairy Program Area; **Michael D. Weiss** is with the Forecasting Support Group.
Appointments in EDD: Thomas F. Davis, Ph.D. University of Pittsburgh, is a research economist with the Income Studies Program Area; **Linda Ghelfi** and **Shirley A. Pryor,** Ph.D. Michigan State University, are with the Income Studies Program Area; **Bernal Green** is the leader of the Health and Education Studies Program Area.
Appointments in NEAD: Robert J. Lenahan, Ph.D. Cornell University, is a consumer economics and demand analysis specialist; **William W. Lin,** formerly with Oak Ridge National Laboratory, is with the Structure and Adjustments Program Area; **Chun-lan Lee Liu,** formerly with the Illinois State Water Survey, is with the Economic Projections and Analytical Systems Program staff.
Reassignments: Stanley Daberkow, formerly with the Regional Analysis Program Area, EDD, Davis, California, is with the Manpower Studies Program, EDD; **Andrew Duymovic,** formerly with the Fruits, Vegetables, Sweeteners, and Tobacco Program Area, CED, is with the FDCD; **Frank Gomme,** formerly with the Grains and Feed Program Area, CED, is with the Office of General Sales Manager; **George Hoffman,** formerly with the Meat Animals Program Area, CED, is at the University of Min-

nesota under the Government Employees Training Act; **John E. Lee, Jr.,** former director, CED, is the director, NEAD; **John L. Okay,** former program analyst, Cooperative State Research Service, is director, Program Evaluation Division, Soil Conservation Service; **James L. Pearson,** former deputy director, CED, is the deputy director, NEAD; **Edward Rall,** formerly with the Poultry Products Program Area, CED, is with the EDD; **Ann G. Sibold** and **William A. Sinclair,** both formerly with the EDD, are with the Office of Management and Finance.

Reassignments in CED: Edward V. Jesse, formerly with the Fruits, Vegetables, Sweeteners, and Tobacco Program Area, is in Davis, California; **Mack Leath,** formerly stationed with the Grains and Feeds Program Area in Prairie Village, Kansas, is in Urbana, Illinois; **Leroy Rude,** formerly with the Grains and Feeds Program Area, Pullman, Washington, is with the Agricultural Policy Analysis Program Area; **Loyd Teigen,** formerly with the NEAD, is with the Forecasting Support Group.

Reassignments in NRED: Verel Benson, formerly with the CED, is with the Resource Studies staff, Lincoln, Nebraska; **Anthony M. Grano,** formerly in Washington, D.C., is leader of the North Central Resource Program Group East Lansing, Michigan; **James B. Johnson,** formerly with the Meat Animals Program Area, CED; **Duane Paul,** formerly with the CED, is with the Environmental Studies staff; **John Putman** is working on a project on estimating agricultural production potential in low-income countries, East Lansing, Michigan; **Harold Stults,** formerly in Denver, Colorado, is the deputy director of Resource Program Studies.

Return: Norman D. Kimball is back with the NRED, Berkeley, California, after a year in Tanzania.

Resignations: Lon Cesal, former leader, Industrial Location Program Area, EDD, is with the Technical Assistance Bureau, Agency for International Development; **Richard O. Wheeler,** formerly with the Meat Animals Program Area, CED, is the director of the Winrock International Livestock Research and Training Center, Little Rock, Arkansas.

Retirement: Olen E. Leonard, formerly with the Manpower Studies Program Area, EDD, Tucson, Arizona.

Washington State University

Appointment: H. Alan Luke, formerly with the Western Dairymen's Cooperative Association, Salt Lake City, Utah, is a professor.

Other Appointments

Donato B. Antiporta, Ph.D. University of Minnesota, is an assistant professor with the Institute of Agricultural Development Administration, University of the Philippines at Los Banos.

Andrew B. Brabrand, M.S. Virginia Polytechnic Institute and State University, is with the Virginia Department of Agriculture and Commerce.

Keith Elsberg, M.S. University of Missouri, is an economic analyst with Edwin Jaenke Associates, Washington, D.C.

Robert H. Hendricks, Ph.D. University of Missouri, is a project director of economics and marketing with the Rural Development Center, Tifton, Georgia.

James House, M.S. University of Missouri, is a commodity analyst with the Louis Dreyfus Corporation, Stanford, Connecticut.

Rolando Jiron, M.S. University of Missouri, is an economist with the Ministry of Agriculture, Managua, Nicaragua.

James E. Kocher, Ph.D. Michigan State University, is an institute associate with the Harvard Institute for International Development, Harvard University.

Roy Kramme, M.S. University of Missouri, is the head wrangler with the Lost Valley Ranch, Sedalia, Colorado.

Gerard McMahon, M.S. University of Missouri, is a research economist with the Jesuit Volunteer Corporations, Center for Science in the Public Interest, Jenkins, Kentucky.

Bekha Lal Maharajan, Ph.D. University of Missouri, is an economist with the Ministry of Agriculture, Kathmandu, Nepal.

Lewis E. Queirolo, M.S. Oregon State University, is an economic analyst with the Commercial Fisheries Entry Commission, Juneau, Alaska.

Enrique Tellez, M.S. University of Missouri, is an economist with the Ministry of Agriculture, Managua, Nicaragua.

Ph.D. Recipients by Subject

Agricultural Economics, General

James C. Cornelius, B.S. University of California, Davis, 1970; M.S. University of Wyoming, 1972; Ph.D. Washington State University, "An Economic Evaluation of the Agricultural Exemption in National Transportation: The Performance of Motor Carriers of Exempt Agricultural Commodities."

Agricultural Finance, Capital and Credit

Kamol Boondiskulchok, B.S. Indiana University, 1970; M.S. Texas A&I University, 1972; Ph.D. Texas A&M University, "Economic Analysis of Correspondent Banking as a Source of Funds to Texas Agriculture."

Gershon Feder, A.B. Tel Aviv University, Israel, 1972; Ph.D. University of California, Berkeley, "Default Risk Indicators in International Borrowing."

William F. Hampel, Jr., B.A. University of Dallas, 1972; Ph.D. Iowa State University, "A Maximum Bid-Price Model to Evaluate Factors Influencing Farmland Values."

Tran Nhu Long, Ingenieur Agronomique National Agricultural Center, Saigon, 1964; Ph.D. University of Florida, "Capital Needs in the Agriculture of South Vietnam."

Fernando Curi Peres, B.S. Federal University of Vicosa, Brazil, 1965; M.S. Federal University of Vicosa, Brazil, 1969; Ph.D. The Ohio State University, "Derived Demand for Credit Under Conditions of Risk."

Lindon Robison, B.S. Utah State University; M.S. University of Illinois; Ph.D. Texas A&M University, 1975, "Financing Agriculture in Southwest Texas—The Role of Commercial Banks."

Kenneth Eugene Stone, B.S. University of Illinois, 1958; M.M.S. Texas Christian University, 1971; Ph.D. University of Illinois, "Effects of a Variable Amortization Payment Plan on the Financial Organization of Illinois Cash-Grain Farms."

Larry A. Walker, B.S. Iowa State University, 1971; M.S. Iowa State University, 1974; Ph.D. Iowa State University, "The Determination and Analysis of Iowa Land Values."

Kenneth Neal Wegenhoft, B.S. Texas A&M University, 1967; M.S. Michigan State University, 1970; Ph.D. Oklahoma State University, 1975, "Micro Effects of Alternative Income Tax Management Strategies on Northwest Oklahoma Farms."

Agricultural Income; Rural Poverty

Gordon L. Myer, Jr., B.S. North Dakota State University, 1965; M.S. North Dakota State University, 1972; Ph.D. University of Missouri, "The Missouri Small Farm Program: An Analytical Evaluation."

Agricultural Labor; Rural Manpower

Geraldo Sant'Ana de Camargo Barros, B.S. University of Sao Paulo, Brazil, 1970; M.S. University of Sao Paulo, Brazil, 1973; Ph.D. North Carolina State University, "Asking Wages, Market Wages, and the Off-Farm Labor Supply by Farm Operators."

Stanley F. Hoppe, B.S. Michigan State University, 1966; M.B.A. Central Michigan University, 1971; Ph.D. Washington State University, "Occupational Mobility of Rural Workers."

Ronald Lance Shane, B.S. University of Nevada, 1968; M.S. University of Nevada, 1971; Ph.D. North Carolina State University, "Labor Supply of Wives and Young Family Members in the Hired Farm Work Force."

Agricultural Products: Demand, Supply, Prices

Mario M. Amin, B.S. California State Polytechnical Institute, 1970, M.S. University of Florida, 1972; Ph.D. University of Florida, "Allocations of Florida Pompom Chrysanthemums to Selected Regional Markets."

Paul Kenneth Blakeley, B.B.A. Loyola University, Chicago, 1968; M.A. McMaster University, Ontario, Canada, 1969; Ph.D. Virginia Polytechnic Institute and State University, "A Quarterly Feeder Cattle Price Forecasting Model with Application Towards the Development of a Futures Market Strategy."

Thomas James Cusack, B.S. University of London, England, 1969; M.S. University of Guelph, Canada, 1971; Ph.D. Oregon State University, "An Analysis of Demand for U.S. Winter Pears in Export Markets."

Vo Huu De, Engineer of Agriculture Saigon National Agricultural Center, 1967; Ph.D. University of Florida, 1975, "Demand for Food in South Vietnam and Projections for 1980."

Gordon T. Gemmill, B.S. London University, England, 1968; M.S.C. Reading University, England, 1969; M.A. Michigan State University, 1974; Ph.D. Michigan State University, "The World

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The names of Ph.D. recipients are provided by departments of agricultural economics and by departments of economics with majors in agricultural economics. The list is for degrees granted in the calendar year 1976, unless otherwise noted.

Sugar Economy: Econometric Analysis of Production and Policies."

Doyle Jeon, B.A. Seoul National University, S. Korea, 1962; B.A. Kon-Kuk University, S. Korea, 1967; M.S. Kansas State University, 1971; M.B.A. Kansas State University, 1973; Ph.D. Kansas State University, "World Wheat Economy: Development of Dynamic Analysis of an Imperfect Market."

Betsey Ann E. Kuhn, B.A. Goucher College, 1970; M.A. Stanford University, 1973; Ph.D. Stanford University, "An Estimation Model for Futures Contract Margin Requirement."

Mark B. Levine, B.S. University of Missouri, 1970; M.S. Cornell University, 1973; Ph.D. Cornell University, "The Use of Information for the Price Determination of Grains for Export."

Thomas Gordon MacAulay, B.S. University of Melbourne, Australia, 1965; M.S. University of Melbourne, Australia, 1970; Ph.D. University of Guelph, Canada, "A Recursive Spatial Equilibrium Model of the North American Beef Industry for Policy Analysis."

Louis A. Pascal Mahe, Ingenieur Agronome, National School of Agricultural Sciences, Rennes, France, 1966; License es Sciences Economiques, University of Paris, France, 1968; Ph.D. University of Minnesota, "An Econometric Analysis of the Hog Cycle in France in a Simultaneous Cobweb Framework and Welfare Implications."

Sharif M. Masud, B.A. University of Dacca, Bangladesh, 1965; M.S. E. Pakistan Agriculture University, Bangladesh, 1967; M.S. University of Illinois, 1973; Ph.D. Washington State University, "A Farm Level Demand and Optimum Allocation of the Pacific Coast Bartlett Pear Industry."

Gordon Stuart Sanford, B.S. University of Connecticut, 1961; M.S. University of Connecticut, 1963; Ph.D. North Carolina State University, "Estimation of Supply and Demand Relationships for Selected Pulses on the Coast of Peru."

James N. Trapp, B.S. Kansas State University, 1969; M.S. Kansas State University, 1971; M.A. Michigan State University, 1974; Ph.D. Michigan State University, "An Econometric Simulation Model of the United States Agricultural Sector."

Stanley Der-Hsiung Wang, B.S. Taiwan Provincial Chung-Hsing University, 1964; M.S. Taiwan Provincial Chung-Hsing University, 1967; Ph.D. Oregon State University, "An Econometric Study of the Canadian Salmon Fisheries."

Abner Willis Womack, B.S. Auburn University, 1964; M.S. Auburn University, 1966; Ph.D. University of Minnesota, "Domestic Demand for U.S. Feed Grains: Corn, Sorghum, Oats and Barley, an Econometric Analysis."

Cooperatives and Cooperation

Anthony Ikpi Ettah Ikpi, B.S. University of Ibadan, Nigeria, 1970; M.S. University of Ibadan, Nigeria, 1972; Ph.D. Purdue University, "An Analysis of Management Decision Making in Agricultural Cooperatives: Some Case Studies."

Bruce L. Swanson, B.S. Ohio State University; M.S. University of California, Davis; Ph.D. Texas A&M University, 1975, "An Economic Analysis of Pre- and Post-Merger Characteristics of Agricultural Cooperative Firms and Implications for Planning, Financing and Growth."

Economic Development, Growth, and Planning

Sohrab Abizadeh, B.S. Pahlavi University, Iran, 1968; M.A. University of New Brunswick, Canada, 1973; Ph.D. Oregon State University, "Tax Components and the Degree of Economic Development."

Donato Baraquia Antiporta, B.S. University of Philippines, 1966; M.S. Indian Agricultural Research Institute, New Delhi, India, 1970; Ph.D. University of Minnesota, "The Structure of Regional Rice Production in the Philippines."

Siddanaik Bisaliah, B.A. University of Mysore, India, 1960; M.A. University of Mysore, India, 1961; Ph.D. University of Minnesota, "Effects of Technological Change on Output, Employment and Functional Income Distribution in Indian Agriculture: A Case Study of the Punjab Wheat Economy."

Peter H. Calkins, A.B. Harvard University, 1968; A.M. Harvard University, 1971; Ph.D. Cornell University, "Shiva's Trident: The Impact on Income, Employment and Nutrition of Developing Horticulture in the Trisuli Watershed, Nepal."

Seok Jung Chang, B.A. Seoul National University, S. Korea, 1965; M.E. North Carolina State University, 1973; Ph.D. North Carolina State University, "An Economic Analysis of the Adoption of New Wheat Varieties under Uncertainty in Ferogepur District."

Anna Luiza Ozorio De Almeida, B.A. San Francisco State College, 1971; Ph.D. Stanford University, "Dualistic Development in Brazil: Industrialization and Demand for Low Skill Services."

Valimohamed Jamal, B.A. Cambridge University, England, 1964; M.A. Stanford University, 1970; Ph.D. Stanford University, "The Role of Cotton and Coffee in Uganda's Economic Development."

Jung je Joe, B.A. Seoul National University, Korea, 1963; M.A. Seoul National University, Korea, 1970; M.S. Kansas State University, 1973; Ph.D. Kansas State University, "An Application of Linear Programming Models to the Growth of Korean Economy through 1981."

Dean A. Linsenmeyer, B.S. University of Nebraska, 1971; Ph.D. Michigan State University, "Economic Analysis of Alternative Development Strategies for Sierra Leone Marine Fisheries."

Bekha Lal Maharajan, B.A. Patau College, Kathmandu, Nepal, 1964; M.A. Tribhuvan University, Kathmandu, Nepal, 1965; M.S. Indian Ag-

ricultural Research Institute, New Delhi, India, 1968; Ph.D. University of Missouri, "An Evaluation of Agricultural Production Systems and Alternatives for Small Farm Areas."

Marshall A. Martin, B.S. Iowa State University, 1966; M.S. Purdue University, 1972; Ph.D. Purdue University, "The Modernization of Brazilian Agriculture: An Analysis of Unbalanced Development."

M. S. Noori-Naini, Dip. University of Tehran, Iran, 1965, Ph.D. Cornell University, "An Economic Analysis of Resource Allocation Issues in Traditional Agriculture: A Case Study of Neishaboor District of Iran, 1969–70."

A. Unal Sarigedik, Agricultural Engineer, University of Ankara, Turkey, 1964; M.S. Oklahoma State University, 1969; Ph.D. Oklahoma State University, "A Simulation Model for Analyzing Alternative Changes of the Oklahoma Economy and Projecting Economic Variables from 1967 to 1985."

Michael J. Schultheis, A.B. Gonzaga University, 1958; M.A. Gonzaga University, 1963; M.A. St. Mary's University, 1966; Ph.D. Cornell University, "Population Growth, Labor Utilization and Regional Development in Uganda."

Teotonio D. Teixeira, B.S. University Federal Vicosa, Brazil, 1967; M.S. University Federal Vicosa, Brazil, 1969; Ph.D. Purdue University, "Resource Efficiency and the Market for Family Labor: Small Farms in the Section of Northeast Brazil."

Manuel R. Villa Issa, B.S. Escuela National de Agricultura, Chapingo, Mexico, 1968; M.S. Colegio de Postgraduados, Chapingo, Mexico, 1971; Ph.D. Purdue University, "The Effect of the Labor Market on the Adoption of New Production Technology in Rural Development Projects: The Case of Plan Puebla, Mexico."

Walter Charles Walden, B.S. Mississippi State University, 1968; M.S. Mississippi State University, 1970; Ph.D. University of Florida, "An Interindustry Analysis of Technological Innovation and Regional Impact: The Case of Flue-Cured Tobacco."

Fred E. Winch, B.S. Cornell University, 1964; M.S. University of Vermont, 1968; Ph.D. Michigan State University, "Costs and Returns of Alternative Rice Production Systems in Northern Ghana: Implications for Output, Employment and Income Distribution."

Energy

Dan Dvoskin, B.S. California State Polytechnic University, 1972; Ph.D. Iowa State University, "A National Model of Energy Use in Agricultural Production."

Environmental Economics; Conservation

James A. Gibson, B.S. University of California, 1971; Ph.D. Iowa State University, "Land Use Processes and Projections: Interrelationships in Iowa Nonagricultural Land Uses."

Ardelle A. Lundeen, B.S. South Dakota State University, 1970; M.S. South Dakota State University, 1971; Ph.D. Iowa State University, "Identifying Land Use Planning Goals of Residents of Region V in Iowa."

Thomas Arnold Stucker, Jr., B.S. Purdue University, 1970; M.S. Purdue University, 1972; Ph.D. University of Illinois, "The Economic Impact of Applying Hypothetical Nonpoint Source Pollution Controls to Hog and Beef Feeding in Illinois."

Food and Consumer Economics

Jagadevappa N. Bagali, B.S. Karnatak University, India, 1956; M.S. Karnatak University, India, 1959; Ph.D. University of Florida, 1975, "Nutritional and Nonnutritional Components of Demand for Food."

Human Resource Development

James E. Kocher, B.S. Ohio State University, 1966; Ph.D. Michigan State University, "A Micro-Economic Analysis of the Determinants of Human Fertility in Rural Northeastern Tanzania."

Industrial Organization; Market Structure

David L. Barkley, B.A. Furman University, 1969; M.A. University of Georgia, 1972; Ph.D. Iowa State University, "The Factors Contributing to Industrial Outmigration from Rural Areas of Iowa."

Steve A. Halbrook, B.A. University of Arkansas, 1973; Ph.D. Iowa State University, "An Analysis of Variables Influencing the Use of the Corporate Form of Organization in American Agriculture."

Victor Kwame Nyanteng, B.S. University of Ghana, 1968; M.S. University of Ghana, 1969; Ph.D. The Ohio State University, "A Study of the Interrelationships Among Elements of Vertical Market Structure, Coordination Practices and Selected Aspects of Market Performance in the Feeder Cattle Industry."

Michael C. Varner, B.S. Pennsylvania State University, 1968; M.S. Pennsylvania State University, 1973; Ph.D. Cornell University, "Advertising and Conglomeration in the Food Processing Industries."

Institutions, Private and Public

David F. Schuy, B.S. Washington State University, 1959; M.A. Washington State University, 1963; Ph.D. Washington State University, "Criteria for the Allocation of Public Waters."

Marketing and Location

Ahmed D. Abou-Bakr, B.S. University of Heliopolis, Cairo, Egypt, 1965; M.S. University of Missouri, 1972; Ph.D. Washington State University, "The United States Sugar Position in the World Sugar Economy."

James A. Akinwumi, B.S. University of Ibadan, Nigeria, 1966; M.S. University of Ibadan, Nigeria, 1971; Ph.D. Cornell University, "Labor Productivity in Fluid Milk Processing and Packaging Operations."

Julio Arroyo Alunan, B.S. University of the Philippines, 1959; M.S. University of the Philippines, 1968; Ph.D. University of Georgia, "An Economic Analysis of the Marketing System for Cattle in the Philippines."

Arvin Ross Bunker, B.S. Arizona State University, 1970; M.S. University of Illinois, 1973; Ph.D. University of Illinois, "Impact of Rail Line Abandonment on Agricultural Production and Associated Grain Marketing and Fertilizer Supply Firms."

Ollie Ancil Cleveland, Jr., B.S. Mississippi State University, 1967; M.S. Mississippi State University, 1970; Ph.D. Oklahoma State University, "Optimum Organization of Gins and Warehouses for Marketing Cotton in the Oklahoma-Texas Plains."

Frank Arthur Dasse, B.S. University of Michigan, 1956; M.B.A. Stetson University, 1972; Ph.D. University of Florida, 1975, "Economic Impacts of Frozen Concentrated Orange Juice Futures Trading on the Florida Orange Industry."

Ernest E. Davis, B.S. Oklahoma State University; M.S. Texas A&M University; Ph.D. Texas A&M University, 1975, "An Economic Study of the Domestic Lamb Marketing Sector—An Interregional Analysis."

Edwardo Diez-Patier, B.S. E.T.S.I. Agronomos, Spain, 1971; M.S. Michigan State University, 1974; M.A. Michigan State University, 1975; Ph.D. Michigan State University, "Efficient Organization of the Fluid Milk Subsystem of Spain."

Donald O. Mitchell, B.S. Montana State University, 1969; M.S. Montana State University, 1971; Ph.D. Iowa State University, "The Level and Variability of Agricultural Exports."

Kenneth Ervin Nelson, B.A. Nebraska Wesleyan University, 1967; M.S. Oklahoma State University, 1969; Ph.D. Oklahoma State University, "A System Analysis of Information and Communication in Beef Marketing."

Alvaro Silva, B.S. Universidad Nacional de Colombia, 1967; M.S. Michigan State University, 1973; Ph.D. Michigan State University, "Evaluation of Food Market Reform: Corabastos-Bogota."

Michael T. Weber, B.S. Southern Illinois University, 1969; M.S. Michigan State University, 1970; Ph.D. Michigan State University, "An Analysis of Rural Food Distribution in Costa Rica."

Oon Lee Yeoh, B.S.A. University of Malaysia, 1966; M.S. North Carolina State University, 1968; Ph.D. University of Florida, 1975, "Welfare Gains from Supply Stabilization in the Orange Industry of Florida."

Natural Resource Economics

Roy Ronald Carriker, B.S. Eastern Illinois University, 1968; M.S. University of Illinois, 1972; Ph.D. Virginia Polytechnic Institute and State University, "Economic Incentives for Institutional Change: The Case of the Virginia Wetlands Act."

John Martin Currie, A.B. University of Manchester, England, 1966; M.A. University of Manchester, England, 1976; Ph.D. University of California, Berkeley, "Property Rights and Agricultural Land: An Examination of the Economics of Agricultural Land Tenure in England and Wales."

Donald E. Eckerman, B.A. California State University, Chico, 1972; M.S. University of California, Berkeley, 1973; Ph.D. University of California, Berkeley, "The Effects of Reservation Systems, Income, and Season on Use of California Campgrounds."

Thomas Adrian Jennings, B.A. Rice University, 1961; Ph.D. University of Florida, 1975, "A General Methodology for Analyzing Demand for Outdoor Recreation with an Application to Camping in Florida State Parks."

Jong-Ying Lee, B.S.A. National Taiwan University, 1966; M.S.A. National Taiwan University, 1969; M.S.A. University of Florida, 1972; Ph.D. University of Florida, 1975, "A Study of the Optimum Number, Sizes, and Locations of Waste Water Treatment Facilities in Alachua County, Florida."

George H. Pfeiffer, B.S. University of California, Davis, 1970; M.S. University of Wyoming, 1972; Ph.D. Washington State University, "Economic Impacts of Controlling Water Quality in an Irrigated River Basin."

Stephen Douglas Reiling, B.S. Southern Oregon College, 1967; M.S. Oregon State University, 1970; Ph.D. Oregon State University, "An Economic Analysis of Policies, Costs and Returns for Public and Commercial Campgrounds on the Oregon Coast."

John Edwin Schefter, B.S. North Dakota State University, 1975; M.S. North Dakota State University, 1968; Ph.D. Oregon State University, "The Demand for and Supply of the Characteristics of a New Residence and the Residential Location Decision."

Oliver Ray Stanton, B.S. Michigan State University, 1964; M.S. Michigan State University, 1966; Ph.D. University of California, "An Investigation of the Effect of Flooding Upon Land Value During the Transition Period from Agricultural to Urban Use and an Analysis of the Benefits Derived from Land Enhancement."

Ashton I. Veramallay, B.S. University of Wisconsin, 1970; M.S. Iowa State University, 1972; Ph.D. Iowa State University, "An Evaluation of Water Resource Developments in Guyana: With Applica-

tion to Selected Drainage and Irrigation Projects."
Gregory K. White, B.A. Vanderbilt University, 1968; M.B.A. University of Alaska, 1973; Ph.D. Washington State University, "The Impact of the Pine Bark Beetle on Recreational Values."

Production Economics and Management

Klaus F. Alt, B.S. Oregon State University, 1968; M.S. University of Illinois, 1969; Ph.D. Iowa State University, "An Economic Analysis of Field Crop Production, Insecticide Use and Soil Erosion in a Subbasin of the Iowa River."
Kenneth Ray Bolen, B.S. University of Illinois, 1962; M.S. Southern Illinois University, 1965; Ph.D. University of Illinois, "Farmer Responses to Market Uncertainty."
Lars G. Brink, M.B.A. Gothenburg School of Economics and Business Administration, Sweden, 1968; M.S. Purdue University, 1972; M.Agr. Agricultural College of Sweden, 1973; Ph.D. Purdue University, "Plans, Decisions, and Results: An Evaluation of a Procedure for Farm Planning Under Risk."
Cecil Wyman Davison, B.S. Oklahoma State University, 1964; M.S. Oklahoma State University, 1965; Ph.D. University of Illinois, "The Economic Effects on Beef Production of Feeding Young Bulls, Administering Growth Stimulants, and Crossing British Breeds."
Noel R. Devisch, Agricultural Engineer, Universiteit van Leuven, Belgium, 1967; M.S. University of Reading, United Kingdom, 1973; Ph.D. University of Missouri, "Application of the Systems Approach: An Information and Decision Model for the Hog Enterprise."
Doeke C. Faber, B.S. McGill University, Canada, 1972; Ph.D. Iowa State University, "Can Agriculture Feed the World: A World Food Analysis."
Craig V. Fulton, B.S. University of Manitoba, Canada, 1967; M.S. University of Manitoba, Canada, 1971; Ph.D. Iowa State University, "Economics of Size of Farm Machinery in Central Iowa."
William Hartley Furtan, B.S.A. University of Saskatchewan, Canada, 1971; M.S. University of Saskatchewan, Canada, 1972; Ph.D. Purdue University, "An Adaptive Economic Approach to Decision Making Under Uncertainty."
Richard Lynn Harwell, B.A. University of Texas, 1951; M.S. Texas A&M University, 1970; Ph.D. Oklahoma State University, "Economic Interaction Between Wheat and Beef in the Southern Great Plains."
Nelson Wayne Jordan, B.S. University of Florida, 1963; M.S. University of Florida, 1964; Ph.D. University of Florida, "A Quantitative Evaluation of the Economic Feasibility of Expansion in the Florida Cattle Feeding Industry."
Wallace E. Killcreas, B.S. Mississippi State University, 1964; M.S. Mississippi State University, 1966; Ph.D. Mississippi State University, "A Computerized System for Estimating the Economic Value and Growth of Natural Timber Stands in Mississippi."
Wayne A. Knoblauch, B.S. Michigan State University, 1971; M.S. Michigan State University, 1972; Ph.D. Michigan State University, "Level and Variability of Net Income for Selected Dairy Business Management Strategies."
Lynn Henry Lutgen, B.S. North Dakota State University, 1967; M.S. North Dakota State University, 1973; Ph.D. University of Nebraska, "Simulation of Crop Production—Marketing Decisions Under Uncertainty for Eastern Nebraska."
Mohammad A. Mian, B.Sc. West Pakistan Agricultural University, M.Sc. West Pakistan Agricultural University, Ph.D. University of Hawaii, "Agricultural Production Models Based on Technical Coefficients Derived from Production and Profit Functions."
Rulon Dean Pope, B.S. Brigham Young University, 1971; Ph.D. University of California, Berkeley, "An Analysis of Factors Affecting Farm Diversification: With Special Reference to San Joaquin Valley Crop Farms."
Richard A. Schoney, B.S. University of Illinois, 1964; M.S. University of Illinois, 1973; Ph.D. Purdue University, "An Economic Analysis of Selected Hay Packaging Systems under Stochastic Weather Conditions."
Dennis L. Thomas, B.S. Iowa State University, 1970; M.S. Iowa State University, 1971; Ph.D. Iowa State University, "American Agriculture in 1980 under Alternative Levels of Crop Exports and Fertilizer Usage."
Roberto Enrique Vazquez-Platero, Ingeniero Agronomo, Universidad de la Republica, Uraguay, 1971; M.S. University of Idaho, 1973; Ph.D. Texas A&M University, "Decision Models for Livestock Production in Uruguay."
David L. Watt, B.A. Graceland College, 1971; M.A. University of Missouri, 1972; Ph.D. Michigan State University, "Michigan's Agricultural Production."
Joel Sylvan Williams, B.S. Louisiana State University, 1969; M.S. Purdue University, 1972; Ph.D. University of Florida, "An Economic Analysis of Alternative Management Strategies for the Spiny Lobster Industry."
Roberto Cristian Zegers Prado, Ingeniero Agronomo, Chile, 1964; M.S. North Dakota State University, 1968; Ph.D. University of Minnesota, "Economic Analysis of Milk Production in Southern Chile."

Public Policy

Jean-Marie DeBois, Graduate University of Louvain, Belgium, 1964; M.S. University of California, Berkeley, 1971; Ph.D. University of California, Berkeley, "Policy Choice, Voting and Prisoners'

Dilemma Game, with an Application to EEC Agricultural Support."

Donald Grant Devine, B.S.A. University of Saskatchewan, Canada, 1967, M.B.A., M.A. University of Alberta, Canada, 1970, 1969; Ph.D. The Ohio State University, "An Examination of the Effects of Publishing Comparative Price Information on Price Dispersion and Consumer Satisfaction."

Robert William Jolly, B.S. University of Minnesota, 1968; M.S. University of Minnesota, 1974; Ph.D. University of Minnesota, "An Econometric Analysis of the Grain-Livestock Economy in Canada with a Special Emphasis on Commercial Agricultural Policy."

John Wayne Murray, B.S. Southwest Missouri State College, 1970; M.S. University of Missouri, 1971; Ph.D. University of Illinois, "Wheat Policies of Major Exporting Countries, 1920–73."

Francis X. O'Carroll, B.S. University College, Dublin, 1961; M.S. Louisiana State University, 1971; Ph.D. Louisiana State University, "An Economic Analysis of a Reserve Stock Program for the United States."

Roger E. Schneider, B.S. University of Illinois, 1968; M.S. University of Illinois, 1970; Ph.D. University of Missouri, "An Evaluation of Disciplinary Analysis of Entry and Exit in Commercial Agriculture."

Regional, Rural, and Community Development

Emmanuel Turkson Acquah, B.S. University of Maryland, 1972; M.S. The Ohio State University, 1976; Ph.D. The Ohio State University, "Labor Productivity and Turnover in Manufacturing Industries: The Case of a Five County Region in Southeastern Ohio."

Kenneth C. Clayton, B.S. Rutgers University, 1970; M.S. Purdue University, 1972; Ph.D. Purdue University, "A Planning Model for Regional Solid Waste Management Systems."

James C. Fink, Jr., B.S. Jacksonville University, 1968; M.S. Pennsylvania State University, 1971; Ph.D. Pennsylvania State University, "An Economic Model for Estimating Work Trip Distributions Between Minor Civil Divisions in Rural Areas."

James David Johnson, B.S. University of Tennessee, 1972; M.S. University of Illinois, 1974; Ph.D. University of Illinois, "Analysis of Economic Composition and Change in Rural and Non-Rural Regions of Illinois."

Dewitt Jones, B.S. University of Arkansas, 1969; M.S. University of Illinois, 1971; Ph.D. University of Missouri, "Income Inequality of Metropolitan Area Size: Importance in Formulating a National Settlement Policy."

Robert Edward Lee, II, B.S. Rutgers—The State University, 1966; M.S. University of Massachusetts, 1969; Ph.D. University of Massachusetts, 1975, "Economic Evaluation of Land-Use Alternatives on the Rural-Urban Fringe."

Antonio Martin Del Campo, Graduate University of Nuevo Leon, Mexico, 1971; Graduate National School of Agriculture, Mexico, 1972; Ph.D. University of California, Berkeley, "Programming Mexican Agricultural Change Recognizing the Heterogeneous Agrarian Structure: A Case Study of Nayarit."

Mbuki Mwamuflya, Licence, Université Catholique de Louvain, France, 1967; M.S. University of California, Davis, 1972; Ph.D. Oregon State University, "Maize Production and Marketing in Four Districts of Zaïre: An Introductory Analysis."

Lynn L. Reinschmiedt, B.S. Oklahoma State University, 1971; M.S. Oklahoma State University, 1973; Ph.D. Texas A&M University, "An Evaluation of Economic Benefits and Costs of Industrialization in Rural Communities in Texas."

Kazen Sayad Sadr, B.S. American University of Beirut, Lebanon, 1969; M.S. American University of Beirut, Lebanon, 1972; Ph.D. The Ohio State University, "Land Use Analysis in a Developing Region: A Study of a Five County Region in Southeast Ohio."

Research Methodology

Edward Ewing Ives, B.S. University of California, Berkeley, 1971; M.S. University of California, Berkeley, 1972; Ph.D. Oregon State University, "Input-Output Models Estimated from Primary Data: Sampling Considerations and Parameter Variability."

Kurt K. Klein, B.S.A. University of Saskatchewan, Canada, 1970; M.S. University of Saskatchewan, Canada, 1972; Ph.D. Purdue University, "An Investigation into the Evaluation of Applied Research Projects in Agriculture."

Sector and Subsector Analysis

Robert A. Bain, B.Ec. Monash University, 1969; M.Ec. Monash University, 1973; Ph.D. Cornell University, "An Econometric Model of the Beef and Pork Sectors: Development and Application to Policy Analysis."

Chung-Liang Huang, B.A. Tunghai University, Taiwan, 1967; M.S. Central Missouri State University, 1972; Ph.D. Virginia Polytechnic Institute and State University, "An Econometric Study on the Market Structure of the World Economy of High Protein Meal with Special Emphasis upon the U.S. Soybean Economy."

John Aloysius Murphy, B.Ag.Sc. National University of Ireland, 1966; M.S. University of California, Berkeley, 1969; Ph.D. University of California, Berkeley, "An Economic Study of the Irish Cattle Industry."

Taxes, Taxation, and Rural Appraisal

Ivery Dwight Clifton, B.S. Tuskegee Institute, 1973; M.S. Tuskegee Institute, 1967; Ph.D. University of Illinois, "Homogeneous Farm Real Estate Markets in the United States: A Multivariate Investigation with a Proposal for Classification and Analysis."

Robert H. Hendricks, B.S. University of Montana, 1956; M.S. University of Missouri, 1971; Ph.D. University of Missouri, "Public Land Employed in Different Predominant Uses: Its Impact on the Finances of the County Court and School Districts in Missouri."

Technological Change

Francisco Manoel da Rocha Pomba Vera-Filho, B.S. Faculdade do Estado da Guanabara, Brazil, 1963; M.S. Ohio State University, 1969; Ph.D. North Carolina State University, "A Study of Changes in North Carolina Peanut Production Processes."

Douglas Leonard Young, B.A. University of Oregon, 1968; Ph.D. Oregon State University, "An Evaluation of Efficiency and Distributional Implications of Changes in Weed Control Technology in Northeast Brazil."

Trade

Tyler Sanford Biggs, B.A. Golden Gate College, San Francisco, 1970; M.S. University of California, Berkeley, 1975; Ph.D. University of California, Berkeley, "Political Economy of East-West Trade: The Case of the 1972–1973 U.S.-Russian Wheat Deal."

Kleo-Thong Hetrakul, B.A. McGill University, Canada, 1969; M.A. Cornell University, 1971; Ph.D. Ohio State University, "The Impact of Changing Trade Policies on U.S. Demand for Income from Feed Grains."

Victor Francisco Palma Valderrama, B.S. Agrarian University, Brazil, 1959; M.S. Federal University of Vicosa, Brazil, 1971; Ph.D. The Ohio State University, "Export Incentive Policies and Economic Development in Brazil."

Land Economics

Robert M. Ronnau, B.S. Kansas State University, 1971; M.S. Kansas State University, 1972; Ph.D. Texas A&M University, "An Economic Analysis of the Dynamic Land Market System in the Edwards Plateau of Texas."

Correction for 1975 Ph.D. Recipients by Subjects, p. 382, as listed in the May 1976 issue is the following: Marlin G. Van Der Veen, B.S. University of Minnesota, 1966; Ph.D. The Pennsylvania State University, "Analysis of Interfarm Variation in Rice Yields: An Economic Study of High Yielding Variety Rice Production in Cavite Province, Philippines.

Ph.D. Recipients by Institution

University of California, Berkeley

Tyler Sanford Biggs
John Martin Currie
Jean-Marie DeBois
Donald E. Eckerman
Gershon Feder
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Obituary

Walter G. Miller

Walter G. Miller, economist with the Federal Highway Administration, Department of Transportation, died on 18 October 1976. Born in Jamaica, West Indies, in 1919, he worked with the Government of Jamaica in a variety of jobs in the agricultural field before migrating to the United States in 1946. His B.S. and M.S. degrees were earned from the University of California, Berkeley, where he was a four-year letterman in soccer. He received his Ph.D. in agricultural economics in 1956 from Iowa State University.

In 1956 he came to Washington, D.C., as an economist with what is now the Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. During his leave from the U.S. Department of Agriculture, 1962–65, he worked with the Food and Agriculture Organization of the United Nations in Rome. He returned to the ERS in 1965, working first with the Natural Resource Economics Division and later with the Economic Development Division. From 1970 to 1974, he was also a professor of economics and statistics at the Federal City College, Washington, D.C. In 1975, he transferred from the USDA to the Department of Transportation as a transportation economist and was with that department until ill health forced his retirement in July 1976.

Miller was a long-time member of the American Agricultural Economics Association, as well as the American Economics Association, Econometric Society, Western Agricultural Economics Association, and the American Statistical Association. He was elected to membership in Phi Kappa Phi and Gamma Sigma Delta, authored and coauthored numerous publications, and received an Outstanding Research Award from the American Farm Economics Association in 1960 and a Sustained Outstanding Performance Award from the USDA in 1961.

He is survived by his wife, Marion, a stepson, Darron, brothers, Harry and Albert, and an aunt, Edith Miller. Walt will be sorely missed by his many friends in the agricultural economics profession.

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case of double counting—perfect collinearity, increase this cost without limit. Alternatively, imposing false restrictions while reducing variance leads to bias, and the worse the restriction, the worse the bias.[3]

In many cases, the investigator may have restrictions in mind such as pooling data, dropping variables, and so on, and he may not be certain whether the restrictions are valid. He may wish the data to reveal something about the truth or falsity of the restrictions. A common practice in such situations is to test the restrictions as a statistical hypothesis. For example, treating equation (2) as a null hypothesis about β, the Snedecor F-test calculates

$$(8) \quad u = \frac{SSE(RLS) - SSE(OLS)}{SSE(OLS)} \frac{T-k}{m},$$

where SSE(·) indicates calculated error sum of squares under either the restricted or unrestricted regressions.

If equation (2) is true, u is distributed as a central F with m and $T-k$ degrees of freedom and can be compared with tabular values for either accepting or rejecting equation (2) as a hypothesis; the outcome depends upon the significance level selected.

Thus, the heuristic notion of pretesting is not so badly placed. If the restrictions are valid, then variances can be reduced without incurring bias. The problem is that one can only test the hypothesis. There is always the chance of accepting false or rejecting true hypotheses. So when the analyst acts as if the restrictions are true (i.e., adopts $\hat{\beta}$, the restricted estimators), he runs a risk associated with type two error. If the restrictions are false, he runs a risk associated with the other type of error involved in hypothesis testing.

The pretest estimator of β based on F-testing a prior hypothesis that a set of restrictions is true is

$$(9) \quad \beta^* = \begin{cases} \hat{\beta} \text{ if } u < \lambda, \\ b \text{ if } u \geq \lambda, \end{cases}$$

where λ is a critical value from the central F and can be associated with the investigator's choice of critical value. The probability characteristics of the β^* estimator are complex. In general, the pretest estimator is biased, since $\hat{\beta}$ is biased if the restrictions are false, given that there is a nonzero probability of accepting false restrictions via the test. The characteristics of the pretest estimator are outlined in a subsequent section.

Often, hypothesis testing is not part of a pretest. The investigator may want to test for structural difference as an end product. It is only when testing leads to a choice among estimators that one is interested in the properties of β^* in equation (9).

The situation becomes even more complex when a string of restrictions are tested in sequence. Stepwise regression programs typically drop (add) a single variable at a time, sequentially screening through a batch of variables. Only a single pretest is considered in this paper, although the single test may involve simultaneous restrictions on many parameters.

Mean-Square-Error Criteria

Whether to adopt restrictions becomes a question of bias-variance trade-off. If restrictions are true, there is no issue, since the imposition of true restrictions reduces variances and does not cause bias. Imposition of false restrictions introduces bias. Thus, the only way of making a judgment on pretest estimators is to adopt either an implicit or explicit utility (or risk) function that assigns weights to bias and variance. Bancroft, in his seminal paper, gave bias tables in a two-variable case; in subsequent work he and his students often have eschewed direct adoption of a single-valued risk function, preferring to give results in a form allowing each investigator to provide his own (implicit) weights. Others have found that several nice results can be obtained by adopting some member of the class of quadratic risk functions. What follows is a brief summary of such functions.

For a scalar case, consider a parameter θ and two potential estimators, $\hat{\theta}$ and θ^*. The estimator $\hat{\theta}$ is defined to be better than θ^* in quadratic risk or MSE if

$$(10) \quad E(\hat{\theta} - \theta)^2 \leq E(\theta^* - \theta)^2.$$

The expectations above are designated MSE, since in the sampling distributions of the estimators the expressions in equation (10) are "mean" or "average" square error of the estimator from the parameter point. MSE is variance whenever the estimator is unbiased.

[3] This could be called the principle of "no free lunch" in regression analysis. For discussion of bias-variance trade-off in a two-variable model, see Wallace.

Otherwise,

$$(11) \qquad \text{MSE}(\hat{\theta}) = V(\hat{\theta}) + [\text{bias } \hat{\theta}]^2,$$

where $V(\hat{\theta})$ is the variance of $\hat{\theta}$.

Whenever a vector of random variables is being considered such as in OLS, RLS, or pretest estimators in a multiple regression model, the notion of mean square error can be generalized in different ways. For example, suppose θ, $\hat{\theta}$, and θ^* are $n \times 1$ vectors. A strong mean square error criterion requires that

$$(12) \qquad \text{MSE}(1'\hat{\theta}) \leq \text{MSE}(1'\theta^*)$$

for every $n \times 1$ vector, 1; that is, for $\hat{\theta}$ to be better in MSE than θ^*, the MSE of every linear combination for $\hat{\theta}$ must be no larger than the same linear combinations for θ^*.[4]

Criterion (12) is equivalent to the requirement that

$$(13) \quad \Sigma_{\hat{\theta}\hat{\theta}} + (\text{bias } \hat{\theta})(\text{bias } \hat{\theta})' - \Sigma_{\theta^*\theta^*} - (\text{bias } \theta^*)(\text{bias } \theta^*)' = A,$$

where A is a nonpositive definite matrix, where $\Sigma_{\hat{\theta}\hat{\theta}}$ is the $n \times n$ variance-covariance matrix for $\hat{\theta}$, bias $\hat{\theta}$ is the $n \times 1$ vector displaying bias terms for $\hat{\theta}$, and similarly for θ^*.

A weaker criterion is to require that

$$(14) \quad E(\hat{\theta} - \theta)'(\hat{\theta} - \theta) \leq E(\theta^* - \theta)'(\theta^* - \theta).$$

Criterion (14) is a direct analogue to the scalar case for MSE. The geometrical interpretation of relationship (14) is that $\hat{\theta}$ is closer, on the average, to θ in squared Euclidian distance.

The criterion in equation (14) is weaker because an equivalent requirement is for the trace of the matrix in equation (13) to be nonnegative. Thus, if $\hat{\theta}$ is better than θ^* in strong MSE, its superiority in terms of the weaker criterion is assured, but not vice versa.

No compelling reasons can be given for acceptance of all or any of the MSE criteria, except that they allow some nice analytical results to be established. Certainly, they are acceptable risk functions in the sense that bias is a "bad" and so are larger variances, but the isorisk curves thus implied are arbitrary. My impression is that part of the lack of acceptance of these or similar risk functions stems not totally from their arbitrariness but that they call attention away from best linear unbiased (BLU) estimators. Of course, the very occasions that call for MSE comparisons are those where unbiasedness is expensive in terms of variance. In a world in which data are cheaply available, BLUness should rank high, since for most estimation contexts, including linear regression, variances are reduced with additional data. For example, in a linear regression context, OLS estimators may have large variances for fixed sample size, but if more data are cheaply available, unacceptably large variances can be overcome by increasing the sample size. Unfortunately for economists, data costs usually are large, requiring in some instances a delay of a year for an additional data point. Thus, unacceptably large variances together with large expenses in obtaining more information in the form of additional sample data dictate the need for restrictions on parameters or the need for data from other sources. Whether additional information in the form of priors or other data regimes is useful can be phrased in terms of bias-variance trade-off using MSE criteria.

[4] This is analogous to the notion of generalized variance. See Toro-Vizcarrondo and Wallace for a necessary and sufficient condition that RLS be better than OLS estimators in a linear regression model.

The Pretest Estimator and Its Risk Properties

The general form of the pretest estimator discussed in this section is given in equation (9). Its characteristics depend upon the distributions of the OLS estimator b and of the RLS estimator $\hat{\beta}$, the critical value for the pretest (λ), and the distribution of the test statistic. This section includes a survey of some results in an example problem first analyzed by Bancroft, as well as results that have been established for the more general case.

The Bancroft Example: A Single Restriction

Bancroft derived expressions for the bias of a pretest estimator in the particular case of deciding whether to drop a regressor in a two-regressor model. Toro-Vizcarrondo extended the Bancroft example to derive MSE of the pretest estimator. Since the Bancroft problem includes many of the ingredients of the larger problem, it is worthwhile to review those results.

The set-up is a linear model with two regressors, X_1 and X_2, with the usual Gauss-Markov assumptions and a normally distributed error. The pretest estimator is for the coefficient of X_1, and the test is for $\beta_2 = 0$. Thus, letting β_1^* be the pretest estimator for β_1,

$$\beta_1^* = \begin{cases} \hat{\beta}_1 \text{ if } u < \lambda, \\ b_1 \text{ if } u \geq \lambda, \end{cases} \tag{15}$$

where $\hat{\beta}_1$ is the least squares estimator for β_1, dropping X_2, and b_1 is the partial regression coefficient linking X_1 to Y with X_2 in the regression. Further, λ is the critical value for the pretest of the hypothesis that $\beta_2 = 0$, and u is the square of the t-statistic usually associated with testing the hypothesis:

$$u = \frac{b_2^2}{s_{b_2}^2}, \tag{16}$$

where b_2 is the regression coefficient of X_2, and s_{b_2} is its standard error.[5]

Under the null hypothesis that the second regressor does not belong in the regression, the u-statistic is distributed as a Snedecor F with 1 and $T - 3$ degrees of freedom. However, not restricting the statistic by the null hypothesis, u is distributed as a noncentral F with 1 and $T - 3$ degrees of freedom and noncentrality parameter θ, where

$$\theta = \frac{\beta_2^2}{2V(b_2)}, \tag{17}$$

where $V(b_2)$ is the true (not estimated) regression variance of b_2. Therefore, the Bancroft set-up presents a choice of either b_1 or $\hat{\beta}_1$ as the estimator for β_1, depending upon a test outcome.

If the investigator chooses $\lambda = 0$, the OLS estimator b_1 is chosen, since the test statistic is nonnegative. The other extreme is to choose $\lambda = \infty$, insuring a choice of the restricted estimator $\hat{\beta}_1$. Therefore, the characteristics of the pretest estimator are related to the characteristics of b_1 and $\hat{\beta}_1$, being closer to those of b_1 for small λ and to those of $\hat{\beta}_1$ for large λ. Since b_1 is unbiased, its MSE is simply $V(b_1)$; $\hat{\beta}_1$ is biased unless X_1 and X_2 are uncorrelated or $\beta_2 = 0$, the bias depending upon the noncentrality parameter in equation (17). Figure 1 shows the typical shapes of MSE's for the RLS, OLS, and pretest estimators.

The shaded triangular area in figure 1 represents the potential for gain via pretest estimation. To the right of A, the OLS estimator dominates any other stepwise estimator; i.e., to the right of A for any pretest critical value λ greater than zero, the MSE of the resulting estimator is no smaller than the variance of b_1. Also, it can be shown that to the left of A the MSE of the pretest estimator is no smaller than MSE($\hat{\beta}_1$). In other words, the MSE function for the pretest estimator with λ in the open interval $(0, +\infty)$ is bounded below by the minimum of MSE($\hat{\beta}_1$) and MSE(b_1).

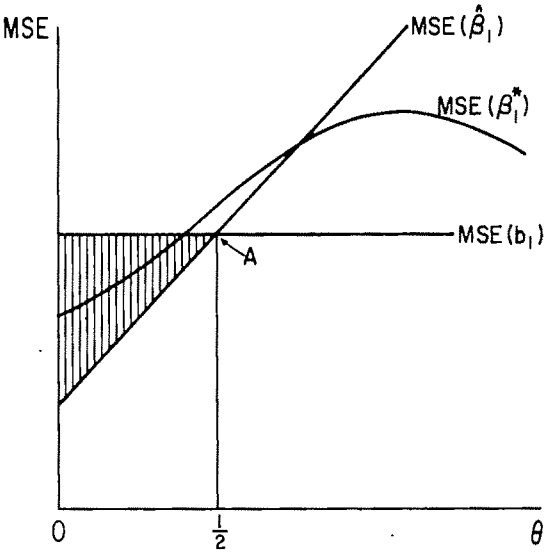


Figure 1. MSE for $\hat{\beta}_1$, b_1, and β^*_1; two-variable case

Since the pretest estimator β^*_1 is a function of three random variables $\hat{\beta}_1$, b_1, and u, the probability density of β^*_1 is the conditional density of $\hat{\beta}_1$ (given $u \leq \lambda$) times the probability that $u \leq \lambda$ plus the conditional density of b_1 given $u > \lambda$ times the probability that $u > \lambda$. Even if $\beta_2 \neq 0$, there is some probability that $u \leq \lambda$ for $\lambda > 0$, so the pretest estimator is biased in general, and the bias and variance of the pretest estimator depend upon the value of β_2, degrees of freedom (sample size), the correlation between X_1 and X_2, and λ, the critical value.

Referring the reader to Bancroft and to Toro-Vizcarrondo for the derivations, table 1 is excerpted from Toro-Vizcarrondo (pp. 60, 67).[6] As derived by Toro-Vizcarrondo, the typical shape of MSE(β_1^*) is shown in figure 1. Regression variance is taken as unity.

The following results are suggested by table 1.

(*a*) For any critical value λ, sample size, and correlation of the X's, increasing the size of

[5] The test could be, and usually is, expressed as a t rather than an F with one degree of freedom in the numerator. In making the transition from the Bancroft problem to the more complex case, it is helpful to use the F notation at this point.

[6] The biases reported by Bancroft are recomputed using modern, large-scale electronic equipment and updated algorithms for numerical intergration. Since Bancroft must have used a hand calculator to perform a tedious task, it came as a pleasurable, mild surprise that Toro-Vizcarrondo's findings to three decimal places coincided precisely with Bancroft's bias estimates.

Table 1. Bias and Mean Square Error for β^*_1, The Pretest Estimator for β_1

β_2	r_{12} 0.2	0.4	0.6	0.8	0.2	0.4	0.6	0.8	0.2	0.4	0.6	0.8
					Bias							
	$T = 5$; $\lambda_{0.05} = 18.51$				$T=11$; $\lambda_{0.05} = 5.32$				$T=21$; $\lambda_{0.05} = 4.41$			
0.1	0.017	0.034	0.051	0.069	0.015	0.030	0.046	0.061	0.014	0.029	0.044	0.059
0.4	0.067	0.134	0.202	0.272	0.049	0.101	0.159	0.227	0.033	0.071	0.122	0.193
1.0	0.142	0.292	0.455	0.649	0.028	0.072	0.164	0.350	0.001	0.006	0.025	0.132
2.0	0.162	0.358	0.627	1.038	0	0	0.001	0.083	0	0	0	0.001
4.0	0.035	0.101	0.282	0.898	0	0	0	0	0	0	0	0
	$T=5$; $\lambda = 1$				$T=11$; $\lambda = 1$				$T=21$; $\lambda = 1$			
0.1	0.004	0.008	0.011	0.015	0.004	0.008	0.011	0.015	0.004	0.008	0.011	0.015
0.4	0.012	0.026	0.040	0.057	0.009	0.019	0.032	0.051	0.005	0.011	0.022	0.041
1.0	0.011	0.025	0.049	0.095	0.001	0.003	0.010	0.039	0	0	0.001	0.009
2.0	0	0.002	0.008	0.043	0	0	0	0	0	0	0	0
4.0	0	0	0	0	0	0	0	0	0	0	0	0
					Mean Square Error							
	$T=5$; $\lambda_{0.05} = 18.51$				$T=11$; $\lambda_{0.05} = 5.32$				$T=21$; $\lambda_{0.05} = 4.41$			
0.1	0.252	0.258	0.273	0.319	0.101	0.106	0.117	0.148	0.051	0.054	0.061	0.080
0.4	0.258	0.281	0.325	0.413	0.107	0.128	0.169	0.246	0.055	0.071	0.105	0.170
1.0	0.284	0.391	0.583	0.901	0.112	0.156	0.272	0.576	0.052	0.063	0.099	0.279
2.0	0.328	0.590	1.142	2.228	0.104	0.120	0.164	0.459	0.052	0.060	0.078	0.140
4.0	0.290	0.472	1.118	3.723	0.104	0.119	0.156	0.278	0.052	0.060	0.078	0.139
	$T=5$; $\lambda = 1$				$T=11$; $\lambda = 1$				$T=21$; $\lambda = 1$			
0.1	0.258	0.289	0.365	0.611	0.104	0.116	0.147	0.245	0.052	0.058	0.074	0.124
0.4	0.260	0.297	0.383	0.646	0.105	0.122	0.162	0.278	0.053	0.062	0.085	0.151
1.0	0.263	0.311	0.428	0.768	0.104	0.121	0.166	0.325	0.052	0.060	0.079	0.151
2.0	0.261	0.300	0.405	0.802	0.104	0.119	0.156	0.281	0.052	0.060	0.078	0.139
4.0	0.260	0.298	0.391	0.696	0.104	0.119	0.156	0.278	0.052	0.060	0.078	0.139

Source: Toro-Vizcarrondo.

the nuisance parameter β_2 first increases bias of β_1* and then decreases it, since if β_2 is close to zero, one tends to do the right thing (throw X_2 away), and as β_2 gets large, one tends also to do the right thing (keep X_2). The same pattern emerges for MSE for the same reason.

(*b*) As the correlation of the two regressors increases, bias and MSE increase for the pretest estimator. However, a rise in collinearity increases the MSE for both the simple and multiple regression estimators for β_1. For example, with $T = 5$ and $r_{12} = 0.8$, MSE($\hat{\beta}_1$) is 10.49, almost three times the MSE of the pretest estimator for the least favorable choice of λ.

(*c*) Lower values of the pretest critical value decrease bias, other things being equal, because low values of λ pull the risk function toward the variance of the multiple regression coefficient b_1. But for low values of β_2, lowering critical values can increase the MSE of the pretest estimators. For example, MSE for the pretest estimator is 0.365 when $\beta_2 = 0.1$, $r_{12} = 0.6$, and $\lambda = 1$, while for $\lambda = 19.51$, the comparable MSE is 0.273. For sufficiently small β_2, there is an MSE gain from excluding X_2; the greater the value of the pretest critical value, the larger the chance of keeping X_2.

(*d*) Increasing the sample size lowers MSE of the pretest, other parameters being constant. As the sample size increases, the test becomes more precise, and unless there are offsetting changes in the other parameters, it becomes more likely that the investigator will make the right decision. The power of the test increases.

The foregoing discussion no doubt leaves some questions in the mind of the reader about the nature of pretest estimators and their relationship to degrees of freedom, the pretest critical value, and the noncentrality and correlation of the regressors. However, it should be clear that trade-offs are involved and that the justification for pretesting is to accept some bias in exchange for variance reduction.

MSE Functions for Pretest Estimators with Multiple Restrictions.

The general pretest estimator β^* is chosen to be either $\hat{\beta}$, the RLS estimator, or b, the OLS

estimator, depending upon the outcome of an F-test (equation (8)). Brook (1972) investigates two different risk functions for β^*:

$$\text{(18)} \qquad \text{MSE}(\beta^*) = E(\beta^*-\beta)'(\beta^*-\beta),$$

and

$$\text{(19)} \qquad \text{MSE}(X\beta^*) = E(X\beta^*-X\beta)'(X\beta^*-X\beta) = E(\beta^*-\beta)'X'X(\beta^*-\beta).$$

Intuitively, MSE(β^*) is the mean square distance of the preliminary test estimator β^* from β, while MSE($X\beta^*$) is the mean square distance for the parameter space $E(Y|X)$ and its estimator.

Even though the researcher might have more interest in the risk characteristics for the β^* estimator, MSE(β^*) turns out to be a function of the X's, among other things. This means that Brook's findings for MSE(β^*) are conditional upon specific problem data in a way that limits the generality of his results. Alternatively, MSE($X\beta^*$) turns out to vary with the values of the regressors, but only through a well-defined parameter, and the Brook results there are more general. Therefore, the characteristics of the risk function for $X\beta^*$ are examined more thoroughly in what follows. (For other examples of scalar risk functions in a similar context, see Farebrother and Sawa and Hiromatsu.)

From Brook, the risk function for the pretest estimator of the conditional expectation of Y, given X, is

$$\text{(20)} \qquad \text{MSE}(X\beta^*) = \sigma^2\{k-m + mr(\theta, \lambda) + 2\theta[1 - 2r(\theta, \lambda) + s(\theta, \lambda)]\},$$

where

$$\text{(21)} \qquad r(\theta, \lambda) = P\left\{F'(m + 2, T - k; \theta) \geq \frac{m\lambda}{m + 2}\right\}$$

and

$$\text{(22)} \qquad s(\theta, \lambda) = P\left\{F'(m + 4, T - k; \theta) \geq \frac{m\lambda}{m + 4}\right\}.$$

The letter P denotes probability, where F' is the noncentral F density with degrees of freedom as indicated and noncentrality parameter θ. In the more general case, as opposed to the Bancroft problem examined earlier, the noncentrality parameter θ is

$$\text{(23)} \qquad \theta = \frac{(H'\beta-h)'(H'S^{-1}H)^{-1}(H'\beta-h)}{2\sigma^2}.$$

Thus, the MSE function for the pretest estimator depends upon the following parameters: (*a*) the regression variance σ^2; (*b*) the number of regressors k and the number of restrictions m; (*c*) the pretest critical value λ;[7] (*d*) the restrictions being tested and the $(X'X)^{-1}$ matrix, but all in terms of a well-defined parameter θ; and (*e*) degrees of freedom $T-k$, but through the probabilities r and s that involve the noncentral F.

Since r and s are probabilities, they are bounded by zero and one. If the pretest critical value λ is assigned either of the two extreme values, zero or infinity, the MSE function in equation (20) reduces to σ^2k and $\sigma^2[k-m + 2\theta]$, respectively, since if $\lambda = 0$, the OLS estimator is always chosen and if $\lambda = +\infty$, the RLS estimator is always chosen.[8]

Characteristics of the MSE function in equation (20) can be brought out with the aid of figure 2. (*a*) For any $\lambda \in (0, +\infty)$, MSE($X\beta^*$) $\leq$ MSE(Xb) for $\theta \leq m/4$. (*b*) The maximum of MSE($X\beta^*$) for nonzero but finite λ occurs to the right of the intersection of MSE($X\hat{\beta}$) and MSE($X\beta^*$), to the right of θ^* in figure 2.

(*c*) MSE($X\beta^*$) for $\lambda \in (0, +\infty)$ is always greater than the minimum of MSE($X\hat{\beta}$), MSE(Xb). In other words, the best that one can do in a least squares framework is to use the restrictions if the noncentrality parameter is smaller than $m/2$, where m is the number of restrictions, and to ignore the restrictions if the noncentrality is greater than $m/2$. Choosing whether to adopt the restrictions on the basis of a test leads to an estimator that is better than ordinary least squares ($0 \leq \theta < m/4$), may be better than restricted least squares ($\theta > \theta^*$), or may be worse than choosing either by some nonstochastic rule.

(*d*) For any finite choice of λ, MSE($X\beta^*$) $\to$ MSE(Xb) as $\theta \to \infty$. The common sense of this is that, if the restrictions are grossly inconsistent with the sample data, one does the right thing—reject the hypothesis that they are valid.[9] (*e*) The closer λ is to zero, the closer

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[7] Rather than λ, the MSE function can be defined in terms of α, a significance level associated with the distribution of a test statistic under a particular null hypothesis. Given a null hypothesis and degrees of freedom, λ and α are in a one-to-one correspondence.

[8] With b being the ordinary least squares estimator, $E(Xb-X\beta)'(Xb-X\beta) = E(\epsilon'X(X'X)^{-1}X'\epsilon) = \text{tr}\, E(\epsilon\epsilon'X(X'X)^{-1}X') = \sigma^2k$. For derivation of the MSE function for the restricted least squares estimator, see Wallace (1972).

[9] One of the reviewers of this paper justifiably complained that it is difficult to get an intuitive feel for θ, the noncentrality parameter. Farebrother pointed out that, since $(H'S^{-1}H)^{-1}$ is positive definite, there exists a matrix P such that $PP' = (H'S^{-1}H)^{-1}$; hence, θ can be written as $(Q'\beta-q)'(Q'\beta-q)$, where $Q' = P'H'$ and $q = P'h$. In a specific problem setting, Q' and q can be derived, and θ is monotonically related to the sum of squares of

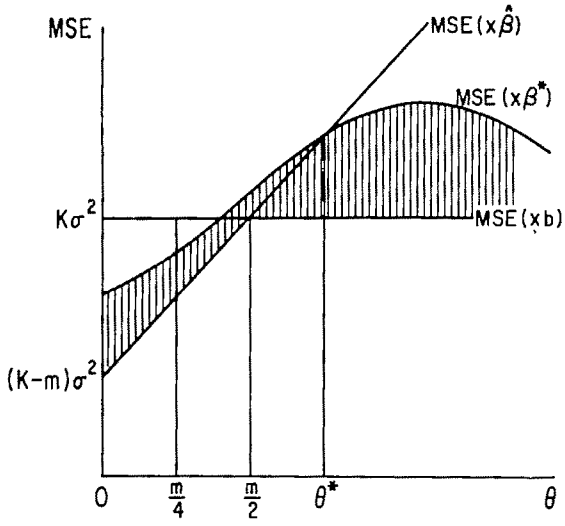


Figure 2. MSE functions for Xb, $X\hat{\beta}$, and a typical MSE function for $X\beta^*$

MSE($X\beta^*$) is to MSE(Xb). Clearly, taking λ close to zero increases the frequency of rejecting a particular hypothesis in repeated samples. So taking small λ (large rejection regions), large regret is avoided to the right of θ^*, but one gives up much chance for large gains in the region $\theta < m/2$. A completely analogous argument can be made for large λ.

The choice being discussed here is dichotomous—either ordinary least squares or restricted least squares, the choice depending upon a test outcome. If one knew the noncentrality parameter precisely, the choice would be clear. Deciding something about θ based on a random variable, in order to make a dichotomous choice of estimators, leads to the sorts of quadratic risk (MSE) properties discussed here.

One conclusion drawn by some is that, at a minimum, the investigator who pretests should choose the critical value with more care than looking it up in a 1%, 5% table. There are many different ways of choosing critical values that are "optimal," two of which are discussed in the section to follow. Various James-Stein type estimators exist that, under certain conditions, have smaller quadratic risk everywhere than the pretest estimator. There are other estimators that are random but nondichotomous, weighted functions of averages of the restricted and unrestricted least squares estimators. These estimators have been shown to have the potential to "clip the corner" of min[MSE($X\hat{\beta}$), MSE(Xb)] in figure 2. Some of these considerations are taken up below.

Optimal Pretest Critical Values

Using the MSE functions depicted in figure 2, the researcher is led to the possibility of choosing an optimal pretest critical value λ as a function of degrees of freedom and number of restrictions being considered. The risk function for the pretest estimator thus defined is a function only of λ, θ, m, and $T - k$. The noncentrality θ is an unknown nuisance parameter in the choice of optimal λ; intuitively, a reasonable choice of λ would be one that pulls MSE($X\beta^*$) close to the minimum of [MSE($X\hat{\beta}$), MSE(Xb)] over the range of θ. As discussed, the risk for the pretest estimator with $0 < \lambda < +\infty$ lies above the minimum of the risk functions for the restricted and unrestricted estimators for $X\beta$.

Depending upon a prior for θ, infinitely many ways exist for choosing an optimal λ. Most of the discussion here centers on a uniform or "blandly ignorant" prior for θ and reports the results of Brook (1976), Sawa and Hiromatsu, and Toyoda and Wallace. Such priors may be too conservative in the direction of large θ, since the very fact that the investigator is interested in a particular set of restrictions presupposes that he must have a prior belief that θ is small, although this is not always the case.[10] The main value in deriving optimal pretest critical values with a uniform prior is to reveal more about the nature of the risk functions. Such critical values also represent a "safe" position for the pretester who has a prior on θ heavily weighted towards zero—safe, that is, when his test statistic is larger than the "optimal" critical value.

error in the restrictions $Q'\beta = q$. Also, θ is bounded above by $(\partial_1/2\sigma^2)(H'\beta - h)'(H'\beta - h)$ and below by $(\partial_m/2\sigma^2)(H'\beta - h)'(H'\beta - h)$, where ∂_1 and ∂_m are, respectively, the largest and smallest characteristic roots of the matrix $(H'S^{-1}H)^{-1}$. For a given problem, H, h, S^{-1}, and hence ∂_1 and ∂_m are known; σ^2, though unknown, does not depend on the validity of the restrictions. Thus, θ is proportional to the sum of squares of restriction errors. A prior on θ that is, say, uniform is also a uniform prior on the sum of squared errors of a set of restrictions; all nonnegative values are equally likely.

[10] Dropping variables mechanically via a stepwise regression package is the obverse. The investigator must feel that the regressors are important; otherwise, why include them in the original regression? Similarly, dropping principal components of the regressors associated with small characteristic roots of the $X'X$ matrix and other ad hoc methods for dealing with ill-conditioned design matrices (multicollinearity) essentially impose restrictions whose associated θ may have no inherent prior weighting toward zero.

The two sets of "optimal" pretest critical values given in table 2 are from Brook (1976) and Toyoda and Wallace. The Brook criterion follows Sawa and Hiromatsu but extends to more than one restriction. The criterion is to find the pretest critical value λ^* that minimizes the maximum regret (maximum risk difference) between $\text{MSE}(X\beta^*)$, $0 < \lambda^* < +\infty$, and the minimum of $[\text{MSE}(X\hat{\beta}), \text{MSE}(Xb)]$. In other words, regret is defined as $\text{MSE}(X\beta^*) - \text{MSE}(X\hat{\beta})$ for $0 \leq \theta \leq m/2$, and $\text{MSE}(X\beta^*) - \text{MSE}(Xb)$ for $\theta \geq m/2$ (see figure 2).

Table 2. Minimum Regret (λ^*) and Minimum Average Risk ($\bar{\lambda}$) Pretest Critical Values with Corresponding Significance Levels

m	$T-k$	λ^*	$\alpha(\lambda^*)$	$\bar{\lambda}$	$\alpha(\bar{\lambda})$
1	2	1.97	0.35	0	1
	4	1.92	0.27	0	1
	8	1.90	0.21	0	1
	16	1.89	0.17	0	1
	24	1.88	0.16	0	1
	60	1.88	0.14	0	1
	120	1.88	0.14	0	1
2	2	2.10	0.35	0	1
	4	2.01	0.26	0	1
	8	1.95	0.20	0	1
	16	1.92	0.16	0	1
	24	1.91	0.14	0	1
	60	1.90	0.12	0	1
	120	1.89	0.12	0	1
3	Any value	n.c.	n.c.	0	1
4	4	2.06	0.25	0	1
	8	1.98	0.19	0	1
	16	1.95	0.15	0	1
	24	1.94	0.14	0	1
	60	1.93	0.12	0	1
	120	1.93	0.11	0	1
5	5	n.c.	n.c.	0.27	0.91
	6	n.c.	n.c.	0.29	0.90
	7	n.c.	n.c.	0.31	0.89
	8	n.c.	n.c.	0.33	0.88
	16	n.c.	n.c.	0.42	0.83
	24	n.c.	n.c.	0.46	0.80
	60	n.c.	n.c.	0.51	0.77
	120	n.c.	n.c.	0.54	0.75
	1,000	n.c.	n.c.	0.60	0.70
8	8	2.02	0.17	0.79	0.63
	16	1.99	0.12	0.98	0.49
	24	1.98	0.09	1.06	0.42
	60	1.95	0.07	1.17	0.33
	120	1.97	0.06	1.22	0.30
24	24	2.01	0.05	1.61	0.13
	60	1.99	0.02	1.75	0.04
	120	1.99	0.01	1.78	0.02
120	120	2.00	0.001	1.93	0.001
	1,000	n.c.	n.c.	1.97	0

Notes: For $m = 1, 2, 3$, and 4, $\bar{\lambda} = 0$, and $\alpha(\bar{\lambda}) = 1$ for all values of $T - k$, not just those listed. The notation n.c. means not calculated. The λ^* and $\alpha(\lambda^*)$ columns are from Brook (1972, table 5.1) and the $\bar{\lambda}$ and $\alpha(\bar{\lambda})$ columns are from Toyoda and Wallace (table 1).

By numerical integration, and for various degrees of freedom, Brook chooses λ^* values that equate the maximum regret on either side of $\theta = m/2$. Any values for λ other than the λ^*'s decreases the maximum regret on one side of $m/2$ at the expense of increasing maximum regret on the other side of $m/2$.

Toyoda and Wallace, assuming a uniform prior on θ, derive optimal values for the pretest critical values $\bar{\lambda}$ by integrating out θ; that is, $\bar{\lambda}$ is chosen by minimizing the difference between $\text{MSE}(X\beta^*)$ and the minimum of $\text{MSE}(X\hat{\beta})$ and $\text{MSE}(Xb)$ over θ. The area minimized is the shaded area in figure 2. The proof of convergence of the integral and other details are provided in Toyoda and Wallace.

Only a selected number of λ^*, $\bar{\lambda}$ critical values are given in table 2. The reader is referred to the Sawa and Hiromatsu, Brook (1976), and Toyoda and Wallace references for additional values. Table 2 also gives significance levels corresponding to the critical values under the central F null hypothesis.

The most striking feature of the critical values generated by minimax regret is their invariance across degrees of freedom. Of course, this invariance leads to considerable variation in pretest significance levels. In contrast, the minimum average risk values are much smaller for small degrees of freedom, being precisely zero for restriction sets of four or fewer, regardless of regression degrees of freedom. This result is because of the small potential for gain in minimizing the integral over θ unless m is fairly large. Thus, on the whole, the Toyoda and Wallace criterion is more favorable to ordinary least squares under a uniform prior. It is worth repeating that, with strong prior on θ weighted towards zero, the minimum average risk critical value could be arbitrarily increased. As numbers of restrictions and regression degrees of freedom get large, the two critical values λ^* and $\bar{\lambda}$ tend toward 2 as indicated by table 2.[11] This implies a symmetry of regret functions for $\lambda = 2$ for large degrees of freedom around $\theta = m/2$.

Brook (1976) produces some results of the relative efficiency of pretest estimators based on the minimax critical value λ^*. He defines

[11] There are no mathematical results in any of the papers cited to support this comment.

relative efficiency as the ratio of the risk of the restricted estimator to the risk of the "optimal" pretest estimator for $\theta \leq m/2$. For $\theta > m/2$, the numerator in the efficiency index is changed to risk of the unrestricted estimator. Graphs of efficiency for $m = 2$, $T = 60$, and $k = 4$, 6, and 8 indicate minimum efficiency at more than 75%. Maximal efficiency is for $\theta = 1$ and is greater than 90% for all three cases considered. Brook (1972) went on to consider maximizing the minimum relative efficiency over θ with respect to λ. This results in slightly larger critical values for $m = 2$ than those obtained by minimax regret (see Brook's table 5.5). Brook's results on minimum efficiency are sketchy but tend to confirm that the worst outcome using his critical values are not too bad. If one concentrates on the β vector rather than $X\beta$ in defining risk, the potential for gain (and loss) in pretesting becomes magnified depending upon how ill-conditioned is the design matrix. Hence, the apparent control of relative risk of the minimax critical value is altered with the choice of risk function.

Stein-Type Estimators

A leading contender to conventional pretest estimators is an estimator that originated in a paper by Stein. His basic notion is to give up unbiased estimators in multivariate situations in favor of reduced MSE. As an example of what is involved, consider $\bar{X}$ as an estimator for μ, given a random sample of size n from any distribution whose mean μ and variance σ^2 exist. As is well known, the sample mean $\bar{X}$ is unbiased for μ, with variance σ^2/n. Is there some other estimator $\hat{\mu}$ with MSE less than $\bar{X}$? The answer is yes, if one is willing to take some bias along with it. Let

$$\hat{\mu} = a\bar{X}, \tag{24}$$

where a is a constant, the mean of $\hat{\mu}$ is $a\mu$, and its variance is $a^2\sigma^2/n$. The MSE is

$$E(\hat{\mu} - \mu)^2 = (a - 1)^2\mu^2 + a^2\sigma^2/n, \tag{25}$$

and choosing a to minimize the MSE gives

$$a^* = \frac{\mu^2}{\mu^2 + \sigma^2/n}, \tag{26}$$

where a^* is smaller than unity, which is typical for Stein-type estimators. The unbiased estimator $\bar{X}$ is "shrunk" by a^*, producing a bias towards zero, but the variance of $a^*\bar{X}$ is smaller than the variance of $\bar{X}$, so that judicious choice of the "shrinker" results in a reduction in MSE.

As is often the case in constructing such estimators, a^* is a function of unknown parameters, including the one of interest. One could estimate a^* by $\bar{X}$ and s^2, the sample variance, but the sampling properties of the resulting estimator are no longer so easily understood. Such questions have been investigated by Holland.

Efron and Morris summarize the difficulties involved with Stein-type estimators, difficulties that they strongly take issue with.[12] They mention distrust of MSE criteria, lack of familiarity with the techniques, as well as the lack of a universal rule of application, requiring various adaptations to various estimation situations, and some feeling among statisticians that one does not buy much with the complications. Efron and Morris give three applications, making their own adaptation of Stein-type estimators, and they claim increased efficiency (relative mean square) over maximum likelihood estimators by several orders of magnitude.

They also state that "The most favorable situation for these estimators occurs when the statistician wants to estimate the parameters of a linear model that are known to lie in a high dimensional parameter space H_1, but he suspects that they may lie close to a specified lower dimensional parameter space $H_0 \subset H_1$. Then estimates unbiased for every parameter vector in H_1 may have large variance, while estimates restricted to H_0 have smaller variance but possibly large bias. The statistician need not choose between these extremes but can instead view them as endpoints on a continuum and use the data to determine the compromise between bias and variance through an appropriate empirical Bayes rule, perhaps Stein's or one of the generalizations of this report" (pp. 46–47, footnote omitted).

In a recent, as yet unpublished paper, Aigner and Judge give a general discussion of Stein-type estimators in precisely the situation described in the Efron and Morris quote. They discuss two types of risk functions on the regression parameter space and give conditions under which Stein-type estimators dominate the pretest estimator for both risk functions. Further, they apply a particular Stein-type estimator to three empirical situations and make evaluation of the results.

[12] The bibliography on Stein-type estimators in the Efron and Morris publication is extensive.

Referring to the general linear model of full rank with a set of potential restrictions on the parameter space, the Aigner and Judge paper uses the following version of a Stein-type estimator. Define $c = (m - 2)(T - k)/(T - k + 2)m$, and take m (hence k) ≥ 3.[13] Let $\beta = \hat{\beta}$ if $u \leq c$ and $= (1 - c/u)b$ if $u > c$, where u is the usual calculated F-statistic based on restricted and unrestricted error sum of squares, $\hat{\beta}$ is the RLS estimator, and b is the unrestricted OLS estimator. This is only one version of the Stein-type estimators considered in the Aigner and Judge paper, but it is the one they used in application. It combines the characteristics of a pretest estimator with a "shrinker." If u is large, $\tilde{\beta}$ approaches the OLS estimator, and if $u < c$, the restricted estimator is chosen. Otherwise, the estimator $\tilde{\beta}$ is a positive fraction times the OLS estimator.

For $m \geq 3$, $\tilde{\beta}$ can be shown superior to both b and any conventional pretest estimator using the MSE function $\text{MSE}(\beta^{est} - \beta)'X'X(\beta^{est} - \beta)$, where β^{est} is any of the estimators. How much better is the question. Unlike the Efron and Morris applications, the Aigner and Judge results are not persuasive that "one buys much with the complications." Aigner and Judge also show that altering the risk function to $E(\beta^{est} - \beta)'(\beta^{est} - \beta)$ produces more stringent requirements for theoretical dominance of Stein-type estimators, conditions that are not met in two of their three applications.

Concluding Remarks

The focus of this paper is on properties of pretest estimators in linear regression, where a single test of a set of linear restrictions on the β space leads sequentially to a choice of OLS or RLS estimators. Pretest estimation of variances or other parameters are related, as is stepwise regression programs that sequentially delete (or add) variables in several steps. The paper relies heavily on Bancroft, Toro-Vizcarrondo, and Brook (1972) as cited previously. Others who have contributed to the literature on pretesting include Bock, Judge, and Yancey (1973a, b), Han and Bancroft, Judge, Yancey, and Bock, and Huntsberger. The most complete bibliography available on the analysis of all such practices is in an unpublished paper by Bancroft and Han.

In a broader sense, pretest estimators fall within the class of all estimators that consciously make a trade for smaller variance at the risk of bias. A Stein-type estimator was selected for brief discussion in this paper. However, the Hoerl and Kennard ridge estimator also could be included in the discussion, as well as such practices as reducing instrumental variables in single or simultaneous equation models by the use of principal components. For a reference on the latter, see Massey.

Viewing exact restrictions as prior information and pretesting as evidence that the investigator is uncertain about those restrictions, other candidates are brought to mind as alternatives to pretesting, namely, procedures that involve a more careful statement of the degree of ignorance of the investigator at an early stage. Nonstochastic inequalities rather than exact restrictions are a case in point. Similarly, uncertainty about restrictions can be couched in a stochastic statement, adding random errors to relationships that are suspected to hold. Stochastic priors may be used in either a classical or Bayesian framework, and the reader may be introduced to these subjects in a linear regression model in Zellner and in Theil and Goldberger, the Zellner book providing analysis of the Bayesian approach.

Stochastic restrictions provide a richer framework for revealing the investigators priors. However, Theil derived a "compatibility test" for stochastic priors in a classical framework that conceivably might reveal to the investigator that, if his basic model is right, there is a large chance that his priors are wrong, or vice versa. If subsequent action is taken in estimation based on the compatibility test, one is right back to the focus of this paper.[14] Likewise, a Bayesian might be led to modify his priors on the basis of a data confrontation. Bad priors can lead to badly biased results in Bayesian as well as classical approaches.

The points covered in the main body of the paper that should be of interest to the applied researcher are as follows. (*a*) Imposing restrictions in regression reduces variances, but false

[13] A requirement for the Stein-type estimator to dominate the pretest estimator in quadratic risk is for the number of restrictions to be at least three in number.

[14] The compatibility test is simply an F-test for pooling data from different sources in a generalized (Aitken-type) regression model when degrees of freedom are too small in one data set (the priors) to run separate regressions. For discussion of the pooling test in this case, see Fisher.

restrictions introduce bias. If data are cheaply available, modeling errors in the direction of overspecification of numbers of variables (or otherwise not accounting for prior information) can be offset, since in most contexts variances reduce as degrees of freedom increase. Mistakes in the other direction—imposing false restrictions—cannot be overcome by increasing the sample size. Biasedness persists with large samples.

(*b*) Probability distributions of pretest estimators, where the final model is selected on the basis of a test outcome, are complex. Standard errors and other measures of reliability as reported in a final least squares run are misleading, sometimes badly so. Hence, the conventional practice of reporting regression coefficients as significant at, say, the 5% level is usually misleading.

Whether to pretest only can be decided using a risk (or utility) function that weighs potential gain from reduced variance against risk of bias. Such a risk function may be implicit or explicit. One such function, arbitrary but exhibiting proper attitudes toward badness of bias and goodness of smaller variance, is quadratic risk or MSE.

Using a particular MSE, one can derive and graphically demonstrate the trade-offs involved as they vary with the truth of the relevant restrictions; that is, the noncentrality parameter in the test statistic may range from zero for valid restrictions to an arbitrarily large number for sufficiently invalid restrictions. (The noncentrality parameter is usually associated with power of the test.)

For the particular quadratic risk function graphed in figure 2, the pretest estimator is always worse than the best of the OLS and RLS estimators over all values of the noncentrality parameter. If the value of the noncentrality parameter in a particular problem is known, the choice is simple. Pretesting arises because the researcher does not know that value.

The risk function for the pretest estimator depends on degrees of freedom, number of restrictions tested, the noncentrality parameter, and the critical value (probability of type one error) for the pretest. For the extreme values of zero and infinity for the critical value for the test, the pretest estimator becomes identical to, respectively, the OLS and RLS estimators. For any nonzero, finite pretest critical value, the risk of the pretest estimator is less than risk for OLS over a range of the noncentrality parameter ($0 \leq \theta \leq m/4$), reaches a maximum somewhere to the right of its intersection with risk of the RLS estimator, and becomes asymptotic to risk for the OLS estimator for arbitrarily large values of the noncentrality. The minimum of the risks for the "never restrict" and "always restrict" estimator provides a lower bound for the risk of pretesting.

(*c*) Optimal pretest critical values have been derived by finding those values that pull the risk of the pretest estimator close to its lower bound. One method is to minimize the maximum deviation of the pretest risk from its lower bound over the noncentrality. This results in critical values of about 2.0 in F testing (about $\sqrt{2}$ in t-tests), which are very stable independently of degrees of freedom. Another method is to minimize the area between the risk of the pretest estimator and its lower bound over the noncentrality. Since this latter method gives equal weight to very large noncentralities, it results in a verdict for never restricting unless one is dealing with at least five restrictions. Thus, given the risk function used and the criterion of minimizing areas, t-testing to delete variables is, for example, ruled out. Of course, one could weight the area to be minimized, given prior information on θ, and this would yield a different result.

From the current results one might try to formulate some rules. The following are suggested but are surely not hard and fast. (*a*) If the researcher thinks certain restrictions are valid based on theoretical consideration or experience in similar situations, impose them without testing. This is a rather innocuous comment, since research must begin by at least some arbitrariness.

(*b*) Using stepwise regression programs to delete variables mechanically is dangerous. If the researcher believes that a variable is important enough to have gathered data for it, his prior on the noncentrality for deleting it is probably not bland. On the contrary, the prior for testing that a coefficient is zero on a variable already included should weight toward large values of the noncentrality, and the Toyoda and Wallace optimal critical values dictate against t-test deletion of variables even with a bland prior.

(*c*) In data-pooling tests, one is never sure whether the structure varies across the sets, but in many cases where structures seem to change slowly, such as cross-section relationships over time, the Toyoda-Wallace critical values are probably overly conservative, leading to not pooling when in fact one should

pool. Here, the Brook critical values may be appropriate, and if the investigator gets an F-statistic smaller than the Toyoda-Wallace critical values, pooling is indicated.

(*d*) Beware of standard errors, t-tests, etc., as reported in a final regression after pretesting. They are misleading and are surely biased in the direction of indicating significance when in fact there may not be any.

In summarizing the material for the practical researcher, it is difficult to avoid a pious Golden Rule: "go thou and construct true models." Such advice is, of course, empty. However, in my opinion, statistical procedures substitute rather poorly for rigorous modeling based on the foundations of the field of application. Rather, statistical technique is a complement, not a substitute. Nevertheless, anyone with experience in empirical work knows that learning is a sequential process and that theory sometimes falls short of providing the sort of prior information one would like. Occasional sinning, therefore, may be inevitable but not necessarily fatal.

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Effects of Energy Cost Increases and Regional Allocation Policies on Agricultural Production

Richard M. Adams, Gordon A. King, and Warren E. Johnston

Some of the impacts of energy cost increases and reduced supplies on the product mix of annual field crops and vegetables in California are analyzed. A quadratic programming model including risk is used to evaluate the effects of increased energy costs and reductions in fertilizer and in fuel supplies. The model includes a demand matrix of some nine field crops and twenty-eight seasonal vegetables. The study also considers the relative impact of energy changes on producer and consumer welfare. Results suggest continued viability of vegetable production but differential consumer and producer impacts associated with energy changes.

Key words: California annual crops, energy costs, quadratic programming, risk.

The 1973 Organization of Petroleum Exporting Countries (OPEC) oil embargo brought into sharp focus the impact on agriculture of cost increases associated with energy (gasoline and diesel fuel) and energy-based inputs (nitrogen fertilizers and pesticides). State and intrastate allocation schemes were proposed. Although present supplies are not restricted, the future may see a repeat of the 1973 occurrence. An unstable energy input structure, resulting from a combination of institutional and market forces, is apt to have a significant influence on both producers and consumers. Producers are affected by changes in relative costs and prices and consumers by changes in product prices. Such energy cost increases have a differential effect on various crops depending, in part, on the importance of such inputs in production costs. The basic thrust of this paper is to quantify the impact of such energy cost increases and quantitative restrictions on the product mix of annual field crops and vegetables in California. The study also raises some methodological points of more general applicability.

Three energy-related inputs that substantially affect the agricultural productivity of land and labor are nitrogenous fertilizers, pesticides, and fuel inputs. The 1972 estimated costs (preembargo) of energy inputs for field crops studied ranged from $12 to $46 per acre, whereas costs for vegetables ranged from $43 to $256 per acre (see table 1). Any analysis of an increase in energy costs requires considerably more information. On the production side, data are required on total variable costs and the associated yield response functions to these inputs. Information on resource availability such as land and water are required. Further, information must be obtained as to the probable price response associated with energy cost increases and with changes in relative prices resulting from a changed product mix. On strictly qualitative grounds, it is difficult to argue the direction of change in production for these field crops and vegetables. Although vegetables have higher costs of energy-related inputs, these costs expressed in relation to total variable costs show as much variation within as between groups (see table 1).

In view of this apparent inability to discern qualitatively any probable impacts, the specific objectives of this study are to evaluate the price, quantity, acreage, and "welfare" effects of (*a*) changes in statewide and subre-

Richard M. Adams is an assistant professor of agricultural economics at the University of Wyoming, and Gordon A. King and Warren E. Johnston are professors and agricultural economists in the Experiment Station and on the Giannini Foundation, University of California, Davis.

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Table 1. Typical 1972 Energy and Total Variable Costs per Acre for Selected California Crops

Crop	Energy Costs			Total	Total Variable Costs	Energy Cost as a Percentage of Total Variable Costs (%)
	Fuel[a]	Pesticides[b]	Fertilizer[b]			
	$/Acre					
Field crops						
Barley	1.65	1.05	8.00	10.70	47.00	23
Beans	5.90	14.50	6.80	27.20	171.50	16
Cotton	5.24	38.00	12.00	55.25	251.90	22
Rice	3.77	14.94	14.00	32.70	150.00	21
Safflower	2.22	0.62	10.00	12.84	51.00	25
Sorghum	2.50	1.05	12.29	16.80	56.00	30
Sugar beets	4.50	23.00	14.00	46.50	217.50	21
Vegetables						
Broccoli	10.70	51.67	77.42	139.80	590.00	24
Cantaloupes	8.60	14.00	20.60	43.20	330.00	13
Cauliflower	10.30	73.90	117.00	201.20	939.00	21
Carrots	9.00	74.00	29.00	112.00	976.00	12
Celery	11.80	115.80	128.40	256.00	2,291.00	11
Lettuce	7.45	93.00	22.00	122.50	988.00	12
Onions	8.90	60.00	35.00	103.90	1,130.00	9
Potatoes	5.70	62.00	39.00	106.70	630.00	16
Tomatoes, processed	7.35	55.49	20.00	82.85	540.00	15

Source: University of California, Agricultural Extension Service.
[a] Includes both diesel and gasoline fuel used directly in production of crops.
[b] Cost reflects prevailing market price (1972) for pesticides (petroleum based) and nitrogenous fertilizer (natural gas based) inputs. Thus, the per acre energy cost for each input represents total cost of material input, including the energy component (petroleum and natural gas) and nonenergy components.

gional energy restraints, (*b*) increases in energy costs, and (*c*) changes in product demand levels. The study also provides some insight as to the effect of introduction of a yield variability coefficient, representing relative risk, in a normative model.[1] Further, the study indicates the applicability of a quadratic programming solution with price-quantity functions included directly into the objective function rather than segmented demand functions reported previously in this *Journal* (Duloy and Norton, Hazell and Scandizzo).

In terms of presentation, the analytical framework is developed with reference to previous research. The results for a base period model (1969–72), including the effect of a risk factor and the effect of statewide versus regional energy restraints, are presented first. Projected 1977 outcomes are quantified, where energy costs and demand levels are varied. The effects of further restrictions on nitrogen and fuel supplies are explored, and in the final section some rough measures of welfare gains and losses to producers and consumers are indicated.

Analytical Framework

Mathematical Model

The basic quadratic programming model is a modified version of the one shown by Takayama and Judge and discussed recently by Duloy and Norton. Specifically, the objective function is of the form:[2]

$$(1)\quad \max \Pi = q'(a + 0.5\,Bq) - c'q^* - c'Dq^*,$$

where q is a vector of aggregate activity levels and q^* is a vector of regional activity levels, expressed in quantity units (e.g., 1,000 hundredweight or 1,000 tons); a and B are elements of the linear demand structure of the

[1] The "variability coefficient" as discussed by Carter and Dean differs slightly from the more widely used "coefficient of variation." Specifically, the variance is defined as the variance of the "random" portion of a time series (reflecting the influence of noneconomic factors such as weather) as computed by the variate difference method, while the mean represents the mean of the last five years. For a detailed discussion, the interested reader is referred to Tintner.

[2] This specification differs slightly from that presented in this *Journal* by Hazell and Scandizzo and Simmons and Pomerada. While these authors express activity levels in hectares and then convert to quantity units consistent with the demand functions through inclusion of average yield matrices, this study presents activity levels directly in terms of demand units and subsequently converts to acreage units. Additionally, the term containing the risk element ($c'Dq^*$) does not appear in the Duloy and Norton formulation and differs from that used in Hazell and Scandizzo and Simmons and Pomerada.

form $P = a + Bq$, where P is an $n \times 1$ vector of prices, a is an $n \times 1$ vector of constants, and B is a negative diagonal matrix of price-quantity slope coefficients (implying zero cross-effects at the farm level); c is a vector of variable cost per unit of output for particular crops by region and soil type; and D is a diagonal matrix of yield variability coefficients.[3]

The objective function is bounded by a convex constraint set of the form $Aq \leq b$, where A is an $m \times n$ matrix of input-output technical coefficients, and b is an $m \times 1$ vector of regional resource availability levels. The maximization of the objective function subject to the restraints is analogous to maximization of the sum of producers' and consumers' surplus under the competitive framework if one is dealing strictly with final products. A further discussion of this issue is in a final section, since there are some intermediate commodities such as feed grains in this model.

On a methodological note, the A matrix consists of 370 production activities and the demand matrix B includes slope coefficients for nine field crops and for twenty-eight seasonal vegetables. The solution procedure incorporates the slope coefficients and intercepts directly into the objective function rather than the segmented demand procedure suggested by Duloy and Norton.[4]

Treatment of Risk

Incorporation of risk in quadratic models was discussed twenty years ago by Freund. Lin, Dean, and Moore have shown the validity of the risk-averse behavioral assumption for crops with large variation in income. Recently, Hazell and Scandizzo have renewed interest in the inclusion of risk in large programming models. Essentially, they add a risk aversion coefficient and a variance-covariance matrix of gross activity returns such that price and marginal returns are equated for each activity. Simmons and Pomerada's study of Mexican vegetable exports utilizes this procedure in testing alternative values of the risk aversion coefficient (from 0 to 1.5) to compare actual with model results.

In this study, risk is confined to yields. Input costs and price-forecasting equations are assumed to remain nonstochastic. The yield coefficient of variation, estimated by the variate difference method (Carter and Dean), is used to modify regional variable cost per unit of output to give a risk cost for each crop. Simmons and Pomerada, after performance of sensitivity analysis, used a constant risk aversion coefficient across crops.[5]

Demand Relationships

Emphasis is on the effect of changes in California production on price. Thus, the general specification of the price-forecasting equations was of the form: season average price received by farmers in California for commodity i is a function of California production, other U.S. production, existing U.S. stocks where applicable, and U.S. aggregate disposable personal income. This formulation was used for all seasonal demand relationships and crops with the exception of cotton, processing tomatoes, sugar beets, and safflower, where market conditions were such that the model seemed inappropriate due to suspected simultaneity. Estimates of these demand relationships were developed from outside sources.[6] The econometric analysis for vegetables indicates significant seasonal variation, using the Logan and Boles testing procedure, with the exception of two crops. Table 2 contains price-quantity relationships as well as R^2's for selected vegetable and field crop price-forecasting equations. The statistical significance of demand coefficients for some

[3] An alternative treatment of risk using yield variability coefficients is to modify the last term, i.e., replace $c'Dq^*$ with $q^{*\prime}CDq^*$, where C is a diagonal variable cost matrix of elements corresponding to the elements of the c vector. Thus, the risk marginal cost rises with the square of quantity produced, and hence the greater the production of a specific commodity, the greater the risk. Such a development would be consistent with conventional risk-diversification procedures. This treatment was not attempted due to expected computational difficulties associated with reformulation of the existing mathematical model objective function.

[4] The quadratic programming problem was solved using a nonlinear programming algorithm developed at the University of California, Berkeley, by Best. This algorithm, identified as FCD (Feasible Conjugate Direction), provided a powerful mechanism for solving problems with nonlinear objective functions constrained by a system of linear equations when interfaced with the University of California, Berkeley, ALPHAC simplex algorithm. The integration of this system of software with the speed of the CDC 7600 provided an expeditious means for solving the numerous parameter alternatives to which the large study problem was addressed. Individual execute times for all model solutions were less than 42 seconds per run.

[5] The yield variability coefficient was used to derive an additional or "marginal" risk cost for each crop by multiplying the variability coefficient times the respective crop per acre variable cost. Then, crop variable costs were adjusted by the addition of this "marginal" risk cost, changing the relative cost structure among crops.

[6] By crop, these estimates are: cotton (Blakely), processing tomatoes (King, Jesse, and French), sugar beets (Bates and Schmitz), and safflower (Houck).

Table 2. Summary of Price-Quantity Relationships for Selected Vegetables and Field Crops

Crop and Season	Adjusted Intercept[a]	Slope Coefficient with Respect to California Production[b]	Price Flexibility with Respect to California Production, 1967–72 Average	R^2
Lettuce				
Winter	9.08	−3.14 E-4	−0.62	0.34
Early spring	12.23	−1.23 E-3	−1.39	0.36
Summer	7.09	−2.02 E-4	−0.42	0.27
Fall[c]	10.31	−5.18 E-4	—	—
Fresh tomatoes				
Early spring[c]	15.88	−3.17 E-3	—	—
Early summer	15.79	−5.75 E-4	−0.12	0.77
Early fall	16.63	−4.68 E-4	−0.13	0.86
Potatoes				
Winter	4.53	−6.95 E-4	−1.47	0.24
Late spring	5.50	−1.48 E-4	−0.81	0.20
Early summer	5.38	−1.26 E-3	−0.81	0.32
Late summer	5.45	−1.22 E-3	−1.11	0.38
Fall[c]	5.40	−4.42 E-4	—	—
Cantaloupes				
Spring	9.54	−1.04 E-3	−0.27	0.68
Summer	8.23	−2.81 E-4	−0.35	0.68
Celery				
Winter	10.06	−1.66 E-3	−0.85	0.52
Spring	9.59	−1.79 E-3	−0.59	0.60
Early summer	7.14	−1.10 E-3	−0.36	0.39
Late fall	7.08	−4.19 E-4	−0.27	0.63
Processing tomatoes[d]	68.00	−2.48 E-6	−0.28	—
Dry edible beans	18.85	−1.30 E-3	−0.25	0.74
Feed grains[e]	1.86	−2.60 E-6	−0.25	0.80
Rice	7.38	−3.90 E-5	−0.17	0.57
Sugar beets[d]	16.01	−2.66 E-3	—	—

Source: Adams.

[a] Independent variables, other than California production, were evaluated at mean levels and added to the intercept term, resulting in a general price-forecasting equation of the form: $Pc_t = a_t + d_tQc_t$. Units of the intercept terms are in dollars per hundredweight for all vegetables (excluding processing tomatoes), dry beans and rice, and in dollars per ton for processing tomatoes and sugar beets. Exceptions are feed grains (dollars per bushel) and cotton (cents per pound).

[b] Units of the slope coefficients are 1,000 hundredweight for most vegetables, rice and dry beans, and 1,000 tons for sugar beets. Exceptions include cotton (1,000 bales) and processing tomatoes (tons).

[c] Due to statistical insignificance of the estimated slope coefficient, the slope coefficient is derived from other season price-flexibilities for the same crop, at relevant price and quantity levels.

[d] Slope coefficient derived from secondary sources (see footnote 6).

[e] The estimated feed grain intercept and slope coefficient are used interchangeably for barley, corn, grain sorghum, and wheat within the base and projection models.

crops is disappointing, forcing the use of slope coefficients for other seasons (table 2).

Production Coefficients and Restraints

The development of the data set for this analysis follows the procedure employed by Shumway et al. More specifically, the data requirements for the model include (*a*) specification of the production regions and the associated cropping activities; (*b*) the regional constraints on land, water, energy, and processing capacities; (*c*) yields and costs for regional cropping activities; and (*d*) the input-output, or technical coefficients for each cropping activity.

Regional definition is facilitated by classification of three key regional determinants—climates, soils, and water costs. To achieve a sufficient level of homogeneity in these factors, fourteen production regions were delineated, each with two irrigable soil types.

Two types of constraints are included in the study: physical resource constraints (land, water, and energy inputs) and institutional constraints (maximum state processing capacity). The constraint levels apply to both the base period and the projection year. Resource availability constraints are adjusted to account for excluded crop requirements, based on actual and projected acreages of perennial crops.

Data on yields and variable costs are obtained from secondary sources (University of California, Agricultural Extension Service) and from consultation with extension personnel and industry representatives. Variable costs of production are disaggregated into energy and nonenergy components to facilitate the measurement of impacts resulting from varying energy cost assumptions. Projected yields are derived from secondary sources. Variable costs for the projection year (before modification to reflect energy cost assumptions) are based on actual and projected movements in nonenergy agricultural input prices.

Base Period Model

The 1969–72 base period model is needed for the comparative static analysis of the projections models. Equally important is its use in analyzing two important questions: (*a*) what effect does the inclusion of a risk factor (yield variability) have on the resulting acreage, production, and prices of model versus actual outcomes? and (*b*) what are the effects of statewide versus regional energy restraints on these same variables?

Effect of Inclusion of Risk Factor

The results of this study provide additional evidence on the importance of specifying risk in normative programming models. Admittedly, our treatment of risk, measured by a yield variability coefficient, is but a first approximation to the more comprehensive analysis proposed by Hazell and Scandizzo and the sensitivity analysis done by Simmons and Pomerada.

The yield variability coefficients for various field crops and vegetables indicate greater variability for vegetables than for field crops (table 3). The effect of introduction of this "risk" factor into the analysis was that acreages of thirteen of the sixteen crops and production of twelve of the sixteen crops were closer to 1969–72 actual levels than when no risk factor was included. Prices (for the weighted average

Table 3. Effect of Introducing Risk Term in Objective Function on Acreage, Production, and Prices, 1969–72 Base Model

	Variability Coefficient Associated with[a]		Acreage		Production		Prices	
Crop	Yield	Gross Income	No Risk	Risk	No Risk	Risk	No Risk	Risk
	------ % -------		---------- % of 1972 Actual ----------					
Field crops								
Beans, dry	n.a.	n.a.	128	127	318	314	46	44
Cotton	7	20	126	129	139	142	152	155
Feed grains	6	5	59	63	68	69	114	113
Rice	6	18	46	47	53	54	126	125
Safflower	18	9	165	165	260	260	114	114
Sugar beets	6	11	60	67	64	72	108	107
Total	—	—	85	88	—	—	—	—
Fresh vegetables[b]								
Broccoli	11	9	157	132	167	140	98	103
Cantaloupes	10–16	15–16	112	100	122	113	71	73
Carrots	7–10	25–32	128	117	130	121	78	79
Cauliflower	7–11	21	88	76	106	92	110	118
Celery	5–16	19–50	127	117	130	120	82	87
Lettuce	6–12	19–33	130	113	126	116	94	101
Onions	6–13	16–39	235	225	297	285	55	58
Potatoes	5–18	26–40	107	94	90	80	102	110
Tomatoes, fresh	5–13	10–27	191	165	202	196	67	69
Total			133	118	—	—	—	—
Processing tomatoes	5	11	177	172	313	280	65	67
Total, all crops	—	—	95	96	—	—	—	—

Source: Adams; for variability coefficients, Carter, Jensen, and Dean.
Note: 1969–72 base model is the statewide energy restraint model.
[a] The ranges in yield and gross income for vegetables are for various seasons.
[b] Data are shown for annual production for the nine fresh vegetables, aggregating the 27 separate seasonal levels used in the analysis.

of seasonal items) were closer to 1969–72 prices for eleven of these sixteen crops. The results are as expected—vegetable acreage (higher yield variability) decreased in the aggregate, while field crop acreage increased.

Review of possible limitations of this approach may lead to better modeling in the future. First, the amount of "improvement" was marginal for some crops. The acreages of safflower, onions, and processing tomatoes are particularly high in relation to actual values. For the latter two crops, acreage is largely contracted by processors; thus, the models do not reflect actual market conditions. For safflower, another contracted crop, the fault appears also to be partly related to the demand specification, since both price and quantity are above 1969–72 levels. Higher production levels for onions and tomatoes interact with the price-forecasting equation to give lower prices. Thus, the observed deviations from actual values (for both nonrisk and risk model specifications) may be partially attributable to demand parameters.

A second problem lies in the use of one yield variability coefficient per crop for the state. A more accurate specification would have yield coefficients vary by region within the state as quantified earlier by Carter and Dean. However, consideration of computational aspects as well as divergences for regional definition between studies precludes the use of regional coefficients. A third question relates to the use of yield versus gross income variability coefficients. No evidence is offered on this point, but a comparison of yield and income variation coefficients in table 3 suggests that such a specification might lower vegetable production in relation to field crops. If income variations are used, questions relating to net versus gross income are important. Further, the work by Just and others suggests the importance of government programs on risk and supply response.

In summary, these findings are offered as indicative of directions for research rather than a convincing argument as to how well normative models can predict—an unlikely goal.

Effect of Statewide versus Regional Energy Restraints

In this section, a comparison is given between two models reflecting actual conditions during the oil crisis. In the first model, energy inputs are treated as perfectly mobile within and across production regions (i.e., only a statewide constraint, set at actual 1969–72 consumption levels, is operative for each energy input). This formulation is consistent with the readily available energy supply situation of the late 1960s and early 1970s. However, as energy input supplies adjusted during the events of 1973–74, several allocation programs were advanced, including a mandatory regional allocation policy. An implicit rationing scheme, in turn, was imposed on agricultural users based on past purchases from respective suppliers. While not totally fixing input supplies within a specific region, this scheme did reduce input mobility. To examine the impacts of a rigid regional allocation policy, a second base model for 1969–72 was evaluated, with each region receiving levels of energy inputs comparable with actual recorded usage.

A comparison of these base model results with actual acreages and seasonal and annual price levels is provided in table 4. The results with respect to acreage levels and prices are not totally unexpected. Imposition of regional energy constraints generally reduced crop acreages, particularly in certain field crops, resulting in an attendant rise in commodity price levels.[7] All commodities but rice experience acreage reductions, reflected in the higher equilibrium prices. Vegetable acreages appear less sensitive to such an allocation scheme, with the exception of processing tomato acreage, which declined sharply (approximately 40%) under the regional energy allocation model.

On a regional level, production patterns displayed no major adjustments across models. While the major production regions experienced reductions in crop acreages, such reductions were similar across regions and largely consistent with the aggregate results. For example, the production pattern of the central coast of California remained primarily oriented towards fresh vegetables; emphasis on specific field crops (e.g., cotton and feed grains) in the Central Valley continued. However, Central Valley production did display rather sharp reductions in cotton and processing tomato acreage with the imposition of regional restraints.

Production and prices varied considerably.

[7] The rise in feed grain prices would take place only without increased levels of interregional shipments. It seems reasonable that other regions would experience similar energy cost increases.

Table 4. Effect of Introduction of Regional versus Statewide Energy Restraints on Acreage, Production, and Prices with Base Period Comparisons

Crop	Acreage			Production			Prices		
	Actual	Energy Restraints		Actual	Energy Restraints			Energy Restraints	
	1969–72	Statewide	Regional	1969–72	Statewide[a]	Regional	Actual	Statewide	Regional
	1,000 Acres			1,000 Tons			$/Ton		
Field crops									
Beans, dry	176	224	157	135	426	307	285	135	197
Cotton	767	993	531	322	457	250	576	396	940
Feed grains	1,270	802	489	2,052	1,421	912	55	62	72
Rice	369	173	223	911	495	644	112	140	138
Safflower	201	332	145	204	531	232	113	130	132
Sugar beets	302	199	192	7,073	5,100	5,054	16	17	17
Total	3,085	2,723	1,737	10,697	8,430	7,399			
Vegetables									
Broccoli	37	49	36	137	192	142	210	215	232
Cantaloupe	58	58	56	433	489	435	141	124	128
Carrots	27	32	29	416	504	465	109	90	94
Cauliflower	20	15	13	97	88	66	198	223	246
Celery	17	20	19	484	583	538	107	95	99
Lettuce	139	158	141	1,649	1,918	1,763	101	102	108
Onions	25	56	34	395	1,130	734	77	39	46
Potatoes	82	77	68	1,305	1,035	864	59	63	70
Tomatoes, processed	182	314	187	4,156	8,172	4,811	33	22	31
Tomatoes, fresh	31	51	48	327	917	846	294	205	210
Total	618	830	631	9,399	15,028	10,664			
All crops	3,703	3,553	2,368	20,096	23,458	18,063			

Source: Adams.
Note: Models include risk factor.
[a] The relationship between production levels and acreage reflects the "optimal" location patterns arrived at in the model solutions. In other words, yields per acre under model production exceed those actually obtained, as reflected in aggregate county data.

The value of production of field crops in the statewide energy restraint model was 96% of actual and in the regional energy restraint model 99% of actual. For vegetables, comparable levels were 125% and 114%, respectively. Total value of production under the statewide restraint was 112% of the 1972 level. Under the regional restraint model, total value of production was 107% of actual level.

Projected 1977 Model Outcomes

This analysis, undertaken during 1974 and 1975, focuses on two major problems: (*a*) what might be the effect on acreage and production under alternative energy cost? and (*b*) what might be the effects on acreage and production of further reductions in nitrogen fertilizer and fuel supplies? The basis of comparison for projected 1977 outcomes is the 1969–72 model with regionally constrained energy levels.

Effects of Changes in Energy Costs and Demand Levels

Several alternative levels of energy costs and product demand levels were explored, but only two alternative energy cost levels are presented here. The two energy input cost structures are referred to as medium-cost (Mc) and high-cost (Hc) models. The first portrays a cost increase equal to the observed or anticipated rise in all farm nonenergy inputs for the period 1972–77 based on data from *Agricultural Prices* (USDA). This medium-cost model results in cost increases for energy and nonenergy costs of 50% above the 1972 level. The high-energy-cost model (Hc) increases energy costs by 70% above 1972 levels, while nonenergy costs are held at the 50% increase.

Three alternative demand assumptions are included in the analysis. The results of the medium-demand assumption, featuring an upward adjustment of the price-forecasting equation intercept by 50%, are reported here.

The medium-demand, high-cost model approximates most closely the current situation and serves as a base model in the following discussion.

The effect of an increase in energy costs, under a given level of product demand (as reflected in price-forecasting equation intercept adjustments from 1972 levels for all crops), is to increase acreage and production of field crops and decrease acreage and production of vegetables (table 5). The overall acreage level increases by about 1%. These results are consistent with expectations, given the high energy requirements of vegetables. It cannot be argued that this is an equilibrium solution unless the full consumer demand reactions are included. This is particularly difficult for crops that are intermediate products (e.g., feed grains) or that have multiple outlets (e.g., vegetables).

Effects of Reduction in Input Quantities

The reduction in input levels would be expected to reduce production, but would this decrease be greater for vegetables or field crops? Results in table 6 indicate that vegetable production is maintained to a greater extent than is field crop production. Acreage of field crops shows a marked increase to reductions in fertilizer supplies. This observation is consistent with lower yields associated with nitrogen reductions and the specification of activity levels, in terms of quantity units, rather than acreage. Thus, given surplus irrigable land in most regions, the solutions reflect the substitution of land for fertilizer.

Combined effects of nitrogen fertilizer and fuel reduction dampen acreage levels from both nitrogen reduction models and 1977 energy level results. Vegetable acreages in all but the low-demand models increase when compared with the 1972 regional energy model. Within the vegetable commodity group, reductions in broccoli, cauliflower, cantaloupe, and potato acreages are offset by substantial expansions of tomato, lettuce, and onion acreages. Such a response appears to indicate that California will remain a significant supplier of vegetables even under rather adverse energy input conditions.

Table 5. Effect of Changes in Energy Costs on 1977 Model Acreage and Production under Medium Demand

	Acreage		Value of Production	
	With Energy Cost		With Energy Cost	
Crop	50% of Above 1972	70% of Above 1972	50% of Above 1972	70% of Above 1972
	-- 1,000 Acres ---		- Index Number[a] -	
Field crops	1,290.9	1,459.9	85	100
Vegetables	942.4	794.0	119	100
Total	2,233.3	2,253.9	108	100

Source: Adams.
Note: Model includes risk factor.
[a] The price weights for index numbers (Laspeyres) are equilibrium prices for the medium-demand, high-cost situation.

Welfare Gains and Losses

Theoretical Arguments

The maximand of the mathematical model is the sum of the areas under the crop demand curves (at farm level) minus supply costs (including risk) associated with the optimal quantities of each crop activity. If one was in a world of markets for final products without time, form, and space dimensions, it would be possible to discuss producers' and consumers' surpluses under the usual caveats associated with such concepts. In this study it is useful to use these concepts, but only under strong assumptions. For example, one might argue that the products are such that the income compensated demand curves are approximately equal to the ordinary demand curves (Dean and Collins). Since many commodities are being considered, it is more tenable to argue that the measures of producers' and consumers' surpluses are the upper bounds to such values.

Market dimensions are ignored, since prices are considered equal at all points in the state. Raw product prices are assumed equal regardless of form (fresh or processed), except for separate specification of fresh and processed tomatoes. The treatment of consumers' surplus must consider final products (e.g., fresh tomatoes) and intermediate products (e.g., feed grains). The measure of consumers' surplus measured at the farm level for a final product equals that measured at the retail level if one has demand functions at both levels separated by a constant dollar marketing mar-

Table 6. Effect of Reduction in Nitrogen Fertilizer and Nitrogen Plus Fuel on 1977 Acreage and Production

Item	Acreage			Value of Production		
	Field Crops	Vegetables	Total	Field Crops	Vegetables	Total
	1,000 Acres			Index Number[a]		
1977 base model	1,459.9	794.0	2,253.9	100	100	100
Reduced nitrogen (N)						
20%	2,062.1	806.2	2,868.3	90	98	96
40%	1,890.2	846.9	2,737.1	89	94	92
Reduced N and fuel						
20%	1,890.3	771.7	2,581.0	85	95	92
40%	1,612.9	677.3	2,290.2	64	80	76

Source: Adams.
Note: Model includes risk factor.
[a] Laspeyres index using prices for 1968–72.

gin (R. King); that is, the two functions are parallel and the point of intersection of relevant demand and supply curves for different market levels is at the same quantity (raw product equivalent) level.

Discussion of consumers' surplus for intermediate products would be incorrect for a complete general equilibrium model, since consumers do not eat feed grains but rather meat and livestock products. Since livestock products are not included, the consumers' surplus associated with some of the field crops is a proxy for the resultant change in consumers' surplus in the final product market. Major emphasis in the analysis is given to change in consumers' surplus from one situation to another, rather than on the absolute magnitude of the values.

As to producers' surplus, this is a return above variable plus risk costs of production and is allocable to "land" (soil quality, water availability, and other restraints) and management. No distinction is made between resource owners and producers.

Empirical Findings

The effects on consumers' and producers' surpluses are discussed under four conditions; they are: (*a*) the effect of statewide versus regionally mandated energy allotments, (*b*) the effect of increased energy costs, (*c*) the effect of reduction in nitrogen supply, and (*d*) the effect of reduction of both nitrogen and fuel supplies.

The imposition of a regional energy allotment is compared with a statewide energy restraint for the 1969–72 base model. As shown in table 7, analysis 1, the regional restraint reduces the total value of the objective function by $264 million, with roughly equal absolute decreases in consumers' and producers' surpluses.[8] Consumer prices generally are higher and quantities consumed lower with the regionally constrained model (see table 3), thus reducing consumers' surplus by 36%. Producer surplus also is reduced by 19%, due to reductions in aggregate production and some changes in specific production patterns, such as a sharp reduction in cotton and processing tomato production in the Central Valley.

The effect of increased energy costs is examined using the 1977 models, which impose the regional energy restraints in all cases (see table 7, analysis 2). As energy costs are increased from 50% to 70%, the value of the objective function decreases by 21%, whereas energy costs are increased by about 13% above the medium base. The decrease in producers' surplus exceeds that for consumers' surplus (including the intermediate products in field crops), whereas the relative decrease is 19% for producers and 24% for consumers.

The effect of absolute reductions in fertilizer supplies are given in analysis 3 in table 7. Reductions of 20% and 40% show little change in

[8] The disaggregation of the objective function into its respective components was facilitated via calculation, across all crops, of net returns, where crop net returns are defined as the difference between gross revenue (determined at the "equilibrium" price levels as established in the solution procedure) and variable costs. This aggregate net return (to producers) was then subtracted from the total value of the objective function, with the resulting residual corresponding to the sum of the area above market or "equilibrium" price and below the price-forecasting equations (consumers' surplus).

Table 7. Welfare Gains and Losses Associated with Alternative Energy Assumptions

Analysis	Consumers' Surplus	Producers' Surplus	Total
	Million 1972 Dollars		
1. Effect of regional energy allotments			
1969–72 base model with energy restraint			
Statewide	383.3	662.3	1,045.6
Regional	244.2	537.8	782.0
Difference	−139.1	−124.5	−263.6
2. Effect of increased cost of energy[a]			
1977 model with energy cost			
Moderate increase (50%) Mc	435.8	671.8	1,107.6
High increase (70%) Hc	332.0	542.5	874.5
Difference	−103.8	−129.3	−233.1
3. Effect of reduction in nitrogen supply of[b]			
20%	320.9	494.9	815.8
40%	345.6	329.0	674.6
Difference	24.7	−165.9	−141.2
4. Effect of reduction in nitrogen and fuel of[b]			
20%	306.4	485.8	792.2
40%	264.8	353.2	617.4
Difference	−41.6	−132.6	−174.8

Source: Adams.
Note: Models include risk factor.
[a] Results shown relate to moderate demand increase assumption with regional energy restraint.
[b] Base model is moderate-demand, high-cost increase shown directly above.

consumers' surplus when compared with the base model. Producers' surplus reductions of $48 and $213 million, respectively, are consistent with the expected optimal set of crop activities. The optimal quantities of each crop remain similar to the levels of the base model, but acreages expand to adjust for lower yields. Thus, producers' gross revenues do not change significantly, while production costs rise in proportion to the expanded acreage, resulting in lower net revenues. Since quantities are about the same, the demand functions give prices that are stable and thus consumers' surplus remains about the same.

The impact of reduced fuel supplies tends to fall on consumers rather than producers. Compare results of analysis 3, where nitrogen only is reduced, with analysis 4, where both nitrogen and fuel are reduced. For a given reduction (20% or 40%), producers' surplus remains fairly stable, whereas consumers' surplus drops sharply (for the 40% reduction, from $345.6 to $264.8 million). This result is due to a change in product mix, where the comparative advantage of commodities (field crops) with the less steeply sloped price-quantity relationships is enhanced relative to vegetable crops having steeper sloped price-quantity relationships. Therefore, the greater percentage reduction in vegetable commodities relative to field crops results in a more severe reduction in consumers' surplus vis-à-vis that of producers.

Viewed from a policy standpoint, information of the above type is needed for analyzing several issues pertaining to agriculture. For example, an important policy observation concerns the impact of combined energy reductions and high fuel costs. The relatively more severe impact on consumers associated with these adjustments suggests that subsidization of fuel in some cases may actually be of greater benefit to consumers than to producers. A similar comparison of the effects of high and low energy costs on consumers indicates that such transfer payments may result in a substantial benefit to consumers.

An additional policy area, though admittedly one not directly addressed in the study, concerns nitrate pollution associated with agricultural activities. Based on model results, it appears that the cost of a policy aimed at reducing ground and surface water nitrate levels via a forced reduction in nitrogen fertilizer application would be borne mainly by producers. Consumers' surplus increases from a level of $332.0 to $345.6 million with a 40% reduction of nitrogen supply; producers' surplus de-

creases from $542.5 to $329.0 million. Although the environment might be improved by a policy of nitrate reduction, the burden obviously falls on the producers under these assumptions. The full welfare implications of such policy measures are complex and involve consideration of compensation principles of the Kaldor-Hicks variety. (For a brief discussion, see Merewitz and Sosnick.)

Summary and Conclusions

This paper has explored some of the impacts of energy cost increases and reduced supplies on the product mix of annual field crops and vegetables in California. The framework is comparative statics using a quadratic programming model. A demand matrix for some nine field crops and twenty-eight seasonal vegetables was entered directly into the objective function. No cross elasticities were considered. The procedure is computationally efficient given large capacity computer facilities.

Introduction of a yield variability coefficient as a measure of risk provided encouraging results for a base-period analysis, but further refinement is needed. The findings add emphasis to the work of Hazell and Scandizzo and Simmons and Pomerada as to the promise of introduction of risk into programming models.

The research findings indicate the adjustments that might be expected in the event of energy cost increases and quantitative restrictions. For example, imposition of energy restraints by subregion would appear to sharply reduce field crop acreage and to increase vegetable acreage. These results are conditional on the validity of the demand and cost specifications. Further, one might expect producers to make technological adjustments over time if this were a permanent change; also the full interregional competitive position of the region is not analyzed in this study.

The effect of increased energy costs, under the given demand specification, was to increase acreage and production of field crops and to decrease vegetable production and acreage. Additionally, restrictions on energy inputs such as nitrogen fertilizer and fuel (from 1972 levels) display effects on production, which, when taken in the aggregate, differ from those observed under the reduction of one input in isolation. For example, when nitrogen fertilizer supplies were cut back, acreage of field crops increased sharply but production still declined. The effect of a cutback in both fertilizer and fuel resulted in sharp reduction in production of both field crops and vegetables.

Such effects are, in part, dependent upon the availability of substitute inputs, such as land and water. Hence, an implication of such energy reductions is a substantial alteration of the derived demand for these resources, which may ultimately affect existing resource project repayment capacities and future feasibility of similar projects.

An attempt was made to isolate the welfare implications of energy changes on producers and consumers, but the use of ordinary rather than income-compensated demand functions and the inclusion of intermediate products are limitations to the analysis. If livestock products were in the model, feed grains would be a production input, and there would be no "consumers' " surplus associated with feed grains. The findings do, however, indicate directions of change that appear valid; namely, alternative energy change assumptions have strong differential effects on consumers and producers. This aspect should be considered in analyses of the impact on agriculture of any proposed energy program.

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Interregional Structure of the U.S. Coal Economy

James D. Libbin and Michael D. Boehlje

A multiperiod spatial equilibrium model of the national coal economy is developed to evaluate future interregional shifts in coal production and the investment requirements and sequencing for exploitation of a nonrenewable, variable quality resource. The effects of alternative sulfur dioxide emission standards and demand growth projections on the location and type of coal production, the transportation industry, and capital markets are examined. The study concludes that the coal industry can expand through 1990, especially in Appalachia and the West, to meet both greatly increased demand and restrictive air quality standards at moderately increased cost.

Key words: air quality standards, coal, spatial equilibrium analysis.

The coal reserves of the United States represent the major proven sources of energy to satisfy increased energy demand during the next decade. Despite the great potential for nuclear power, further research must be undertaken to determine the long-term effects on the environment and the safety of this source. Domestic natural gas and petroleum reserves are being rapidly depleted, while uninterrupted flows from imports have become less certain. Additionally, the "fuels of the future" such as synthetic fuels and solar and geothermal power will probably not make significant contributions to energy supply before 1985 (Federal Energy Administration 1974, 1976).

The purpose of this paper is to analyze the impact of various policy decisions on the future development of the U.S. coal industry. Specifically, the results emphasize the regional reallocations of production necessary to meet projected growth in coal demand and the economic consequences for the coal industry of imposing alternative sulfur dioxide emission standards on coal-burning facilities. A description of the analytical model used in the analysis—a multiperiod interregional competition model—is presented in the next section. The empirical results, including a discussion of the competitive position of major coal-producing areas and an analysis of the effects of alternative sulfur dioxide emission standards, follow, along with concluding remarks and suggestions for further study.

The Analytical Framework

The coal mining and distribution complex is characterized by a depletable, heterogeneous product, an interregionally competitive structure, and demand functions that, because of governmental regulations on air quality and emissions, exhibit important quality as well as quantity dimensions. The time sequence and location of investment in new mines is a critical factor in the ability of the coal mining industry (as well as end-users of coal) to respond to expanded consumption. Consequently, a multiperiod, interregional competition model was formulated to evaluate the optimal adjustments required of various sectors of the U.S. coal industry (mining, washing, transportation, and consumption) to meet increased demand and more restrictive environmental standards. This normative interregional framework facilitated consideration of quality dimensions of the product (sulfur content and heating value), transportation costs and constraints, the efficient interregional structure of production, and investment requirements and sequencing for a nonrenewable resource.[1]

James D. Libbin is a research associate and Michael D. Boehlje is an associate professor of economics at Iowa State University.

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[1] Although interregional competition (spatial equilibrium) mod-

The objective function of the model is designed to minimize the total discounted cost of mining, washing, and transporting coal, reclaiming strip-mined land, and constructing new mines, subject to constraints on mining equipment availability, known coal reserves, current mining capacity, sulfur dioxide emission standards, and the projected demand for coal. Cost minimization is justified on the basis of firm size, the competitive structure of the industry, and the behavior of utilities (the major users of steam coal) to obtain competitive bids.

Eighteen demand and twenty-one supply regions are specified with unique points of origin and destination (tables 1 and 2). Also shown in table 1 are the four major producing areas. Four time periods are specified: 1976–77, 1978–80, 1981–85, and 1986–90. New mine expansion before 1981 is limited to the number of new mines currently planned by the industry (Coal Age). The quantity of coal mined in any time period is limited to current mining capacity plus any new capacity added through subsequent investment; the total quantity of coal mined must not exceed available reserves. Coal washing is the only means of quality upgrading allowed, and rail is the only mode of transportation included.[2] Both surface and underground mining are included in the analysis, and mining of both thin and thick seams is considered in production regions with widely variable overburden and seam thickness characteristics.

els have been frequently used in agricultural economics (e.g., Heady and Srivastava, Takayama and Judge), their application to the energy and coal industries is relatively new (Nagarvala, Ferrell, and Olver; Schlottman; Federal Energy Administration 1974, 1976; LeBlanc) with the exception of early work by Henderson. Similarly, the utilization of intertemporal allocation models is not unique in agricultural economics research (Takayama and Judge, Swanson). However, few examples of empirical analyses that have combined intertemporal and interregional dimensions in an allocation model are available.

[2] Washing refers to the beneficiation processes generally used by the majority of eastern coal producers to rid the coal of dirt, rocks, other foreign matter, and some of the pyritic and sulfate forms of sulfur.

Table 1. Supply Regions and Model Quality Parameters

Region	City of Origin	Average Btu Content (Btu/Lb.)	Run-of-Mine Sulfur Content[a]		Washed Coal Sulfur Range
			Average[b]	Range	
			Lbs. $SO_2/10^6$ Btu		
Northern Appalachia					
Maryland	Baltimore	13,029	2.1	1.7–3.9	1.1–2.6
Ohio	Zanesville	12,490	6.3	1.1–7.9	1.0–4.7
Pennsylvania	McKeesport	13,491	3.5	1.0–6.3	1.6–2.8
Virginia	Pulaski	13,748	1.1	1.0–1.6	1.2
West Virginia	Beckley	12,480	2.3	1.2–5.4	1.1–3.6
Southern Appalachia					
Alabama-Georgia	Birmingham	14,271	1.6	0.8–5.8	1.5–3.8
Eastern Kentucky	Hazard	13,737	1.6	1.4–4.7	1.2–3.5
Tennessee	Knoxville	13,678	2.6	1.2–5.3	1.2–3.4
Midwest					
Arkansas-Missouri	Clinton, Mo.	11,155	7.5	7.5	5.8
Illinois	Mt. Vernon	11,355	7.7	4.3–8.3	3.0–5.9
Indiana	Bedford	13,280	2.9	2.8–2.9	1.9–2.1
Iowa	Oskaloosa	11,746	7.1	7.1	5.2
Western Kentucky	Madisonville	12,513	7.4	7.4	4.3
Oklahoma-Texas	Denison, Tex.	7,822	3.8	3.8	NW[c]
West					
Colorado	Steamboat Springs	13,296	0.6	0.6–0.7	NW
Montana	Forsyth	8,416	0.96	0.96	NW
New Mexico	Albuquerque	10,618	1.3	1.3	1.1
North and South Dakota	Minot, N. Dak.	6,700	2.1	2.1	NW
Utah	Provo	12,047	1.5	1.5	NW
Washington	Centralia	8,000	1.5	1.5	NW
Wyoming	Rawlins	9,400	1.1	1.1	NW

[a] Btu and sulfur content data are condensed from input data shown in Levins et al., pp. 73–93. Up to three quality levels, with unique Btu and sulfur content parameters, are designated for both run-of-mine and washed coals and for each producing region. A total of sixty-four distinct quality grades were programmed.
[b] Weighted average of all reserves.
[c] No coal washing allowed.

Table 2. Demand Regions and Regional Sulfur Dioxide Emission Standards

Region	City of Destination	Regional Sulfur Standard (Lbs./SO_2/10^6 Btu Input)
Northeast (Me., N.H., Vt., Mass., R.I., Ct., N.Y., N.J., Md., Del., D.C.)	New York, N.Y.	1.2
Pennsylvania-Ohio	Pittsburgh, Pa.	1.2
Middle Atlantic (W. Va., Va., N.C., S.C.)	Danville, Va.	2.3[a]
Florida-Georgia	Valdosta, Ga.	1.2
East South Central (Ky., Tenn., Ala., Miss.)	Chattanooga, Tenn.	1.2
Michigan	Detroit	2.4[b]
Illinois-Indiana	Chicago, Ill.	1.8
West North Central (Wis., Minn., N. Dak., S. Dak.)	St. Paul, Minn.	2.4
Iowa	Des Moines[d]	6.0[c]
Eastern Missouri	St. Louis	2.3
Western Missouri	Kansas City	3.2
West South Central (Kans., Nebr., Okla., Tex., Ark., La.)	Salina, Kans.	3.0
West (Mont., Wyo., Colo., N. Mex., Id., Utah, Ariz., Wash., Oreg., Nev., Calif.)	Salt Lake City, Utah	1.2

[a] 1.6 lbs. after 1980.
[b] 1.6 lbs. after 1977.
[c] 5.0 lbs. after 1977.
[d] Des Moines is the central point of six Iowa destinations.

Final demand for steam coal is specified exogenously by using demand estimates from the *Project Independence Report* (Federal Energy Administration 1974). The annual demand for coal in each region (measured in British thermal unit [Btu] content rather than tons) in 1976–77 is specified as equal to 1973 consumption; thereafter, demand is increased linearly to 130% of 1973 consumption by 1990. Additional analyses that assume 1990 consumption to be 150% of the 1973 base are also completed.[3]

Coal mining and washing costs vary by region, depending upon mining type, economies of size, seam thickness, overburden thickness, and reclamation requirements. Intraregionally, mining cost differentials depend on seam thickness and mining type. All costs are held constant throughout the time horizon of the model, as there is no basis for differential rates of change in cost by region, and uniform percentage increases in per unit costs will not affect the competitive position of the various producing regions. Future financial streams are discounted to reflect the fact that individuals and society have a positive time preference for money. The discount factor is calculated as a geometric weighted average of annual treasury bill rates to reflect a risk-free, pure time preference for money (Harris and Nehring).

One of the major environmental concerns with respect to the future development of coal is the level of sulfur dioxide emissions from burning. Four sets of sulfur dioxide emission standards are chosen for analysis: 5.0 pounds, 3.0 pounds, and 1.2 pounds of sulfur dioxide per million Btu in all regions, and a set of regional standards currently implemented or slated for future compliance by state legislatures (table 2). The 3.0 pound standard approximates the coal quality being burned by electricity generation plants and other users in the early 1970s, while the 5.0 pound standard represents a relaxation that some argue is nec-

[3] This exogenous specification of demand does not recognize the concept of price elasticity of demand. Recent studies indicate that the short-run price elasticity of demand generally falls within the limits of −0.123 to −0.259 (Appalachian Resources Project). Thus, projections of coal demand that ignore the price effects will overstate future consumption. Including price explicitly in the model would mandate a quadratic formulation, which would result in sacrifices in detail in other parts of the analysis. When this analysis was undertaken, *Project Independence* (Federal Energy Administration 1974) coal demand projections were the best and most recent available. Additionally, the 1973 edition of *Coal—Bituminous and Lignite* (U.S. Dep. Interior 1975) was the latest complete source of coal production and consumption data. Most recent editions indicate an increase in coal consumption of 8.7% between 1973 and 1975. Similarly, more recent Federal Energy Administration (1976) projections indicate demand increases should fall within a range of 59% to 109% by 1985, centering on a 72% increase. Comments on the implications of greater demand increases are presented later in this article. The interested reader should consult the *Project Independence* and *National Energy Outlook* reports (Federal Energy Administration 1974, 1976) for more detail on the demand growth assumptions.

essary to allow sufficient coal production to reach goals of energy independence. The regional standards represent a compromise between current operating procedures and more strict federal regulations, while the 1.2 pound standard represents the proposed federal Environmental Protection Agency guidelines. With respect to coal quality, sixty-four distinct quality levels are specified with up to six levels for each supply region. Of the total number of quality levels, thirty-seven are run-of-the-mine grade, while the remaining twenty-seven are washed grades of coal. Because the sulfur content of a particular region's coal determines the technical feasibility of use and the cost competitiveness of processing to reduce sulfur content, the quality of the resource is crucial in evaluating the competitive position of various production regions. An entire specification of all data and data sources, as well as additional discussion of the model structure, may be found in Levins et al.

The mathematical programming model used in the analysis can be summarized as

$$(1)\quad \min Z = \sum_i\sum_m\sum_r\sum_t \alpha_t a_{imrt} M_{imrt} + \sum_i\sum_m\sum_t \alpha_t b_{imt} N_{imt} + \sum_i\sum_s\sum_t \alpha_t c_{ist} P_{ist} + \sum_i\sum_j\sum_q\sum_t \alpha_t d_{ijt} T_{ijqt}$$

subject to mining restrictions:

$$(2)\quad \sum_r M_{imrt} \leq MC_{imt},$$

$$(3)\quad MC_{imt} = \beta_t MC_{im,t-1} + k_{im} N_{imt},$$

and

$$(4)\quad \sum_t M_{imrt} \leq R_{imr};$$

washing restrictions:

$$(5)\quad V_{irt} + \omega_{is} P_{ist} \leq \sum_m M_{imqt};$$

transportation restrictions:

$$(6)\quad \sum_j T_{ijqt} \leq V_{irt} + P_{ist};$$

demand and sulfur emission restrictions:

$$(7)\quad \sum_i\sum_q \psi_{iq} T_{ijqt} \geq D_{jt},$$

and

$$(8)\quad \sum_i\sum_q \frac{W_{iq}\psi_{iq} T_{ijqt}}{D_{jt}} \leq Y_{jt};$$

capital availability restrictions:

$$(9)\quad N_{imt} \leq N^*_{imt};$$

and additional restrictions:

$$(10)\quad M_{imrt}, P_{ist}, N_{imt}, T_{ijqt} \geq 0;$$

where Z is total cost; i is a particular supply region such that $1 \leq i \leq 21$; j is a particular demand region such that $1 \leq j \leq 18$; m is mining type such that $m = 1$ for surface mining and $m = 2$ for underground mining; q is a particular quality level encompassing both sulfur dioxide and Btu content, designations varying by regions such that $1 \leq q \leq 6$; r is a particular unprocessed quality level such that $r = \{q|1 \leq q \leq 3\}$; s is a particular processed quality level such that $s = \{q|4 \leq q \leq 6\}$; and t is a particular time period such that $1 \leq t \leq 4$. For the corresponding combinations of subscripts, the remaining variables are defined such that α_t is the discount factor in time period t (5.845% per year); a_{imrt} is mining plus reclamation cost per ton of coal; M_{imrt} is the quantity of coal mined; b_{imt} is the investment required to construct a new mine; N_{imt} is the number of new mines constructed; c_{ist} is the washing cost per ton of coal; P_{ist} is the quantity of coal washing; d_{ijt} is the cost of transporting one ton of coal; T_{ijqt} is the quantity of coal transported; MC_{imt} is the mining capacity of all existing mines; β_t is depletion factor (5% per year);[4] k_{im} is the capacity of a newly constructed mine; R_{imr} is the total available reserves; V_{irt} is the amount of coal transported without washing; ω_{is} is the inverse of the fractional weight recovery from washing coal; ψ_{iq} is the heating value of coal in Btu per ton; D_{jt} is the quantity of coal demanded measured in Btu; W_{iq} is the sulfur dioxide content contained in coal measured in pounds of sulfur dioxide per million Btu; Y_{jt} is the maximum allowable emissions for coal mixtures burned measured in pounds of sulfur dioxide per million Btu; and N^*_{imt} is the currently planned expansion of new mines.

The variable Z contains a complete accounting of the costs of extracting coal within the mine, investments in new mines, and the costs of washing and transporting coal and reclaiming strip-mined land. Constraints on the mining activities are identified by equations (2), (3) and (4), which require that gross mining activity can be no greater than the available mine capacity, specify that the mine capacity in any time period is equal to 95% of the mine capacity of the previous period plus any new mine construction, and require that the total mining activity not exceed the available reserves.

Washing constraints (5) require that the sum

[4] Both new and existing mines were assumed to have a useful life of twenty years. Five percent of existing mine capacity was depleted each year (β_t).

of unwashed coal shipments and original weight of washed coal shipments not exceed the mining activity within each supply region. The transportation constraints (6) specify that the sum of coal shipments from any supply region can be no greater than the sum of unwashed and washed coal produced in that region. Demand and sulfur emission constraints (7) and (8) insure that the sum of the amounts of coal transported into a particular demand region, multiplied by its relevant Btu value, shall not be less than the total demand in that region measured in Btu, while the total sulfur dioxide emissions shall not exceed the specified standard. The capital availability restrictions (9) limit new mine expansion, before 1981, to the number of new mines currently planned by the industry (Coal Age).

Empirical Results

The results of the regional sulfur standards are discussed first (assuming a 30% growth in demand by 1990), with the discussion that follows noting the adjustments in area market share and interregional shifts suggested by alternative sulfur dioxide emission standards.

Regional Sulfur Standards

Average annual coal production is summarized in table 3. Also shown is the actual tonnage and share of the U.S. market mined in the four major producing areas in 1973, the change from 1973 to 1990, and 1990 share of the U.S. market as predicted by the model. Figures 1 and 2 summarize the interregional coal shipments in two periods: 1978–80, the first period involving an increase in demand, and 1986–90, the long-run situation. Similar diagrams for 1976–77 and 1981–85 may be found in Levins et al.

The results indicate that few major adjustments in the location of production are needed to operate in the long run under the regional sulfur emission standards. Little change occurs in the market shares of each coal-producing area in 1986–90 compared with actual 1973 production. Thus, even with more restrictive sulfur standards in some regions than presently exist, the industry could expand sufficiently to meet the projected growth in demand. In all four of the major production areas, however, significant interregional reallocations are suggested, and some transporta-

Table 3. Average Annual Regional Coal Production, Regional Sulfur Standard Assumptions

Region	Actual 1973 (1,000 Tons)	1973 Percentage of U.S. Market	Average Annual Production by Period				1986–90 Change from 1973 (%)	1986–90 Percentage of U.S. Market
			1976–77	1978–80	1981–85	1986–90		
			1,000 Tons					
Northern Appalachia	273,384	47.1	223,912	253,631	243,639	304,725	11.5	50.8
Maryland	1,789		1,744	1,520	1,119	0	−100.0	
Ohio	45,783		23,303	20,411	86,376	115,261	151.8	
Pennsylvania	76,403		89,092	88,904	76,809	109,154	42.9	
Virginia	33,961		36,712	33,265	79,335	80,311	136.5	
West Virginia	115,448		73,061	109,531	0	0	−100.0	
Southern Appalachia	101,415	17.5	109,681	108,504	114,169	110,790	9.2	18.4
Alabama-Georgia	19,230		22,950	29,646	28,842	31,953	66.2	
Eastern Kentucky	73,966		76,516	68,871	71,018	66,948	−9.5	
Tennessee	8,219		10,214	9,987	14,309	11,889	44.7	
Midwest	148,380	25.6	85,684	79,287	140,199	133,012	−10.4	22.1
Arkansas-Missouri	5,092		0	0	0	0	−100.0	
Illinois	61,572		28,277	24,652	12,294	10,867	−82.4	
Indiana	25,253		26,854	26,646	125,486	119,370	372.7	
Iowa	601		0	1,533	0	0	−100.0	
Western Kentucky	53,679		30,554	26,636	2,419	2,775	−94.8	
Oklahoma-Texas	2,183		0	0	0	0	−100.0	
West	56,589	9.8	80,708	85,169	59,640	52,587	−7.1	8.7
Colorado	6,233		3,382	4,631	1,867	0	−100.0	
N. & S. Dakota	6,906		0	0	0	0	−100.0	
Montana	10,725		23,930	22,910	8,904	0	−100.0	
New Mexico	9,069		9,297	9,846	0	0	−100.0	
Utah	5,500		0	0	10,094	11,312	105.7	
Wash.-Oregon	3,270		0	0	0	0	−100.0	
Wyoming	14,886		44,100	47,782	38,776	41,275	177.3	

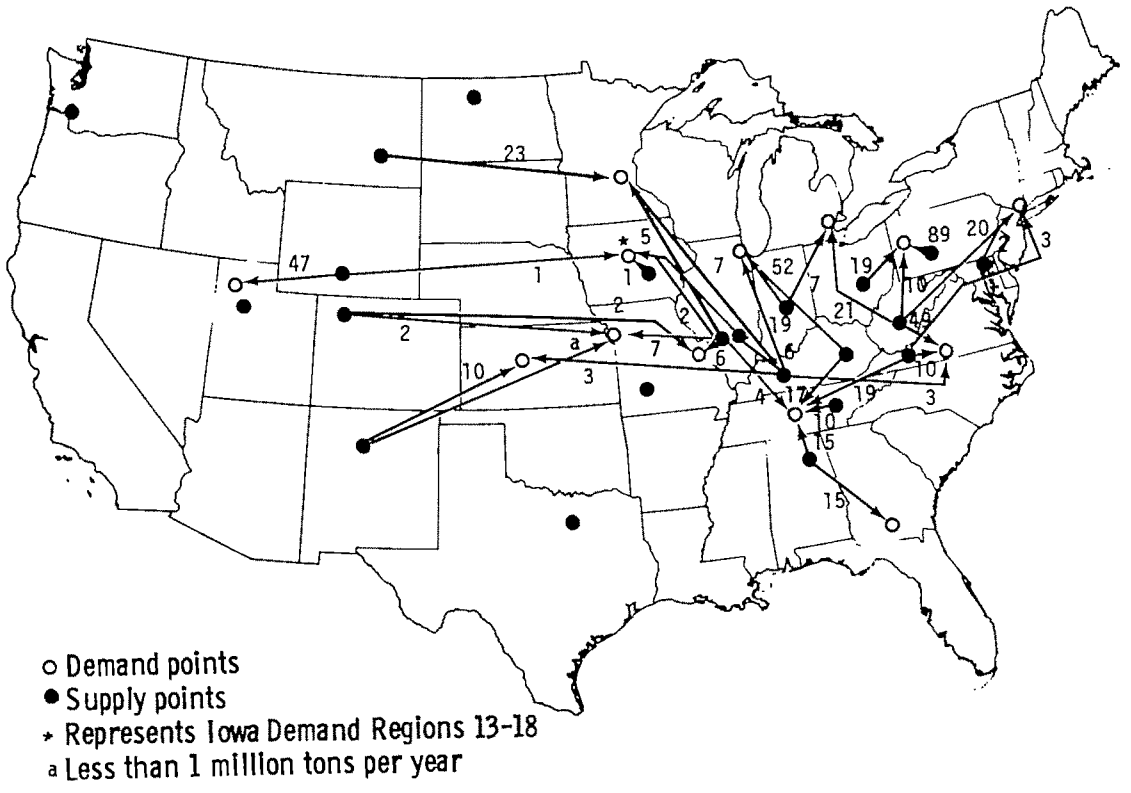


Figure 1. Coal shipments 1978–80 (million tons per year)

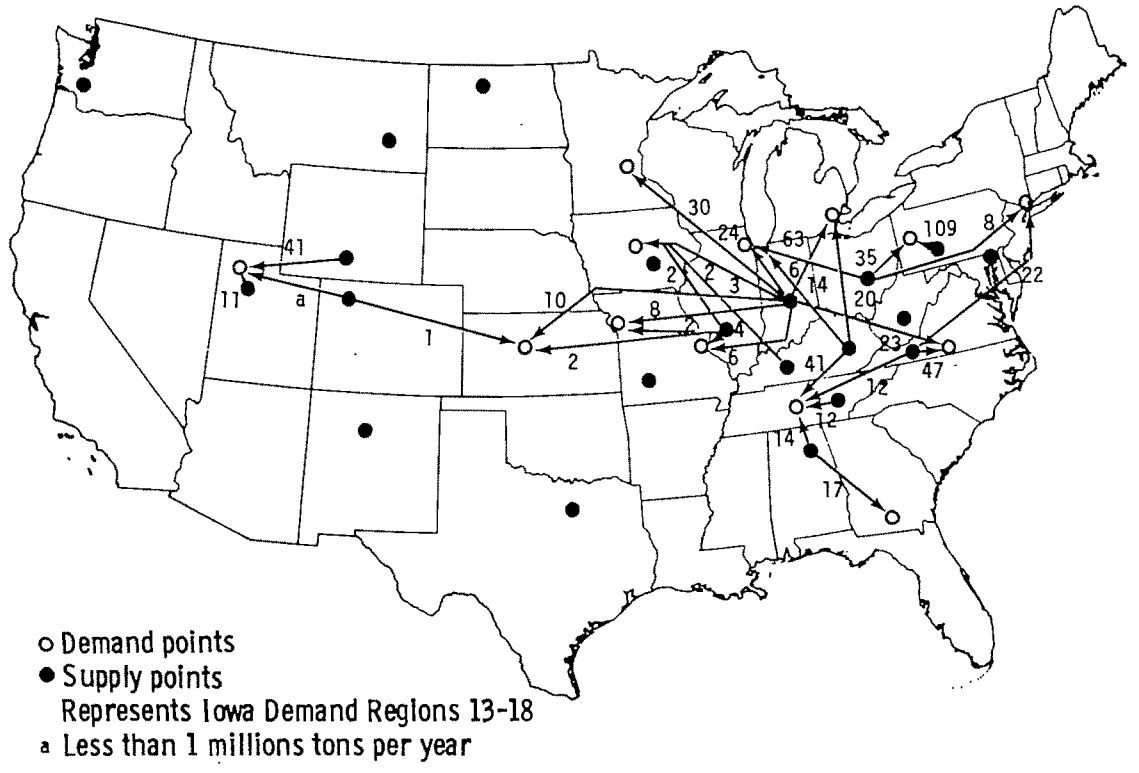


Figure 2. Coal shipments 1986–90 (million tons per year)

tion difficulties are foreseen. Much of this reallocation is necessary to use the higher quality reserves within each area. Other adjustments occur to exploit those geologic formations suitable to large-scale, low-cost mining and to take advantage of geographic locations with low transportation costs.[5]

In the West, the demand for Montana, Wyoming, and New Mexico coal is strong before 1981. After capital constraints are released, however, all the demand for western coal is supplied by Utah and Wyoming. Significant expansion occurs in the eastern coal-producing regions of Alabama-Georgia, Indiana, eastern Kentucky, Ohio, Tennessee, and Virginia after 1980. Although western mining costs are much lower than those in the eastern United States, the high transportation costs to move low Btu coal to eastern demand centers offsets the scale economies of western mining. Also Bureau of Mines washability and demonstrated reserve data indicate that adequate untapped reserves of eastern coal of sufficient quality are available for washing to meet the regional sulfur standards (Cavallaro, Johnston, and Deuerbrouck; U.S. Dep. Interior 1974). Without indicating the magnitude of shipments, shadow prices suggest that washing costs will have to be at least double those used in this analysis ($1.00 per ton) before western coal will be substituted for eastern washed coal after 1980.

Two important interregional shifts that reflect cost competition and resource availability interactions should also be noted. Indiana dominates its closest competitor, Illinois, in most scenarios analyzed. Indiana coal has both a lower sulfur and higher Btu content. When capital constraints are eliminated and new mines can be developed, Indiana production expands rapidly and Illinois production declines. Indiana depletes its reserves very rapidly before 1990, more rapidly than may be technically feasible or politically acceptable. Further analysis indicates that coal from eastern Kentucky and the West would probably substitute for Indiana coal if limits were placed on the rate of mine expansion in Indiana.

When long-run adjustments can be made, coal production in Virginia increases by 135%, and West Virginia production is reduced to almost zero. These dramatic shifts occur partly because of the specification of the supply and demand points in the model. The choice of demand points in the populous areas of the eastern United States results in consistently higher transportation costs to deliver West Virginia coal compared with coal from surrounding production regions. Shadow prices suggest that a relative change in total delivered costs (mining, processing, and transportation) of only $0.04 in favor of West Virginia would improve its long-run competitive position.

To produce the quantity of coal suggested by the model in the 1981–90 periods, a substantial number of new mines must be developed. Major mine construction activity is projected for Ohio, where 112.5 million tons of new annual strip-mine capacity are added in 1986–90. Other regions experiencing significant expansion in 1981–90 and the corresponding amounts of new annual strip capacity are Indiana, 105.0 million tons; Virginia, 62.3 million tons; eastern Kentucky, 47.6 million tons; and Pennsylvania, 20.4 million tons. The implications for land use and reclamation problems and conflicts in these regions are evident. Local land use policies and other externalities may tend to dampen the more dramatic expansion results. Only fifty underground mines with an average capacity of 930,000 tons per year are opened in the United States in 1981–90.

Because the results suggest concentration of production in regions with high quality reserves, serious coal transportation problems could occur. Although transportation constraints were not explicitly included in the model, most producing regions distribute their coal to numerous demand points, thus minimizing large shipments over single routes. Three regions, however, shipped amounts far in excess of actual 1973 shipments to specific demand points. All the Montana production is shipped into the North Central demand region, resulting in a flow five times greater than the 1973 movement. Also, 53% of Virginia's increased production goes into the Virginia-Carolina consumption area. The most serious transportation bottleneck is in the Midwest, where 60% of Ohio's 1986–90 production

[5] Solutions predicting zero or greatly reduced production for a particular region must be interpreted carefully. The model really suggests that these regions do not have a comparative advantage in coal production and expansion should not be encouraged under current conditions, not that all existing mines should be closed. Given the aggregative nature of an interregional competition model, two points of caution should be mentioned: (*a*) aggregation bias can distort results, and (*b*) individual firm behavior may differ from the "efficient" aggregate results. A firm with a large investment in a producing region may continue to produce as long as returns are sufficient to cover variable expenses.

(nearly 63 million tons per year) is shipped to Illinois-Indiana, compared with near zero shipments between these regions in 1973. The concentration of coal production in fewer regions will certainly aggravate already difficult transportation problems.

Alternative Sulfur Standards

One indication of the potential increase in the costs to the coal industry and to society in general of meeting increasingly strict emission standards for the period 1976–90 is the change in the value of the objective function as the sulfur standards are changed. The values of the objective function, when expressed in cents per million Btu, are 27.4¢, 27.8¢, 29.3¢, and 30.9¢ for the 5.0 pound, 3.0 pound, regional, and 1.2 pound standards, respectively. These figures are not of the magnitude expected for delivered market prices because they contain no allowance for profit and are in present-value terms. Costs increase by 1.2%, 5.5%, and 4.5% as standards are changed from 5.0 pounds to 3.0 pounds, 3.0 pounds to regional standards, and regional standards to 1.2 pounds. Thus, reducing sulfur emissions by 60% from 3.0 pounds to 1.2 pounds would require a cost increase of 11.4%.[6]

Part of the cost increase is caused by the regional concentration of production and the decline of the Midwest, with its geographic advantages, as a major producing region, thereby raising the total transportation bill. Also, more coal is washed with the more stringent sulfur standards, incurring an added cost of $1.00 for every ton washed. The greatest part of the cost increase is caused by the growth in high-cost underground mining, which accounts for 14.0%, 19.2%, 26.9%, and 31.2% of total production at the 5.0 pound, 3.0 pound, regional, and 1.2 pound standards, respectively. Thus, more restrictive sulfur standards discourage strip mining and favor expansion of underground mining. This effect is due primarily to a relatively higher concentration of low sulfur coal in the nation's underground reserves (U.S. Dep. Interior 1974).

Table 4 outlines the changes in coal production for the four major production areas, the four specified time periods, and the 5.0 pound, 3.0 pound, and 1.2 pound standards. As sulfur dioxide standards become more restrictive, those areas with lower sulfur content coal and competitive costs increase their share of the U.S. market dramatically.

The northern Appalachian area is least affected by changes in sulfur standards, producing 41.2%, 41.6%, 50.8%, and 41.6% of total U.S. coal consumption in the 1986–90 period under the 5.0 pound, 3.0 pound, regional, and 1.2 pound standards, respectively (compared with 47.1% in 1973). Northern Appalachia can

[6] An additional solution using a 1.5 pound standard indicates that a 50% reduction of emissions (from 3.0 pounds to 1.5 pounds) could be obtained for only a 6.5% cost increase.

Table 4. Average Annual Coal Production for Three Alternative Sulfur Standards

Area	Actual 1973 Production (1,000 Tons)	1973 Percentage of U.S. Market	Average Annual Production by Period				1986–90 Changes from 1973 (%)	1986–90 Percentage of U.S. Market
			1976–77	1978–80	1981–85	1986–90		
			1,000 Tons					
			5.0 Pound Sulfur Standard					
Northern Appalachia	273,384	47.1	205,379	236,499	238,381	255,184	−6.7	41.2
Southern Appalachia	101,415	17.5	104,294	94,017	26,491	14,483	−85.7	2.3
Midwest	148,380	25.6	99,905	104,381	241,387	302,735	104.0	48.9
West	56,589	9.8	85,020	87,075	52,811	46,791	−17.3	7.6
			3.0 Pound Sulfur Standard					
Northern Appalachia	273,384	47.1	199,898	240,170	224,287	253,556	−7.3	41.6
Southern Appalachia	101,415	17.5	108,288	98,011	51,316	55,452	−45.3	9.1
Midwest	148,380	25.6	102,730	92,696	218,953	248,386	67.4	40.7
West	56,589	9.8	86,926	92,547	60,656	52,542	−7.2	8.6
			1.2 Pound Sulfur Standard					
Northern Appalachia	273,384	47.1	264,162	256,433	237,149	254,818	−6.8	41.6
Southern Appalachia	101,415	17.5	109,681	108,504	196,776	224,559	121.4	36.6
Midwest	148,380	25.6	35,287	37,970	20,902	14,786	−90.0	2.4
West	56,589	9.8	92,293	134,190	111,200	118,943	110.2	19.4

be characterized as having a relatively large mine size, substantial surface and underground reserves, and relatively short haul routes to the major demand centers in the industrial Northeast and Midwest.

Southern Appalachia, with generally higher quality coal than northern Appalachia, faces locational disadvantages reflected in higher transportation costs as compared with either northern Appalachia or the Midwest. Therefore, when sulfur standards are relaxed and low sulfur coal does not have a comparative advantage, the southern Appalachian area produces far less than its 1973 U.S. market share of 17.5%. As sulfur standards become more restrictive and midwestern coal becomes unusable, the southern Appalachian area dramatically increases production in absolute as well as relative terms. Southern Appalachia produces 2.3%, 9.1%, 18.4%, and 36.6% of 1986–90 U.S. consumption under the 5.0 pound, 3.0 pound, regional, and 1.2 pound standards.

The Midwest has the most to lose if the more restrictive federal sulfur dioxide standards are adopted and enforced by state authorities. Because of the high sulfur content of its coal, the Midwest decreases production dramatically as standards are tightened, producing 48.9%, 40.7%, 22.1%, and 2.4% of 1986–90 consumption under 5.0 pound, 3.0 pound, regional, and 1.2 pound standards (the Midwest's market share in 1973 was 25.6%). The locational and transport advantages of the Midwest are irrelevant under tight sulfur standards because of the inability to sufficiently reduce the sulfur content of its coals with current washing technology.

The West is an important source of future coal production in the view of many analysts. The results of this study, however, are less encouraging for the development of western coal than past reports. Although the West does increase production as sulfur standards are tightened, the long distances (and resulting high transportation costs) coupled with low Btu content discourage the use of the lower sulfur western coals in favor of eastern underground coals. The West produces 7.6%, 8.6%, 8.7%, and 19.4% of 1986–90 U.S. consumption under 5.0 pound, 3.0 pound, regional, and 1.2 pound sulfur standards. Even though western production nearly doubles from 9.8% of the 1973 market to 19.4% of 1990 consumption, under the 1.2 pound standard, no western coal is shipped to points east of the Mississippi River.

The effect of increasingly strict sulfur emission standards is dramatically illustrated by changes in the production of low- and high-quality coal in Kentucky, a state that overlays two major production areas, southern Appalachia and the Midwest. Under the relaxed 5.0 pound sulfur standard, western Kentucky shows a 33% increase in production from 197[illegible] to 1990. The more strict regional and 1.2 pound standards make it too costly to use western Kentucky, low-quality coal even for blending. On the other hand, eastern Kentucky's more expensive, higher quality coal plays a major role in meeting the national coal demand under the regional and 1.2 pound standards but is an insignificant source under the 5.0 pound standard.

The shifts in production within each of the four major producing areas as sulfur standards are varied should also be recognized. The results indicate that in northern Appalachia the major suppliers of coal for all emission standards are Virginia, Ohio, and Pennsylvania. Ohio and Pennsylvania combined produce nearly the same amount of coal under each of the four sulfur standards, but Ohio production declines and Pennsylvania production increases as standards become more restrictive. In the southern Appalachian area, Alabama-Georgia and eastern Kentucky are major coal producers in all situations except with the 5.0 pound and 3.0 pound standards and western Kentucky under the 5.0 pound standards. Western coal production is concentrated in Montana, Utah, and Wyoming. Most of the interregional shifts are caused by the relative availability of various qualities of coal and the geographic advantages that translate into low transportation costs.

Processing capacity does not seem to present any serious problems for the coal industry before 1980 for even the restrictive 1.2 pound standard but may be a serious impediment to growth after that year if new technology (gasification or stack gas scrubbing) is not available to efficiently reduce the sulfur content of coal. Potential transportation problems discussed earlier are aggravated even more by the increasingly strict sulfur standards because a larger quantity of the nation's coal must come from those few production regions with low sulfur reserves.

For the coal-mining industry to expand production into higher quality reserves, capital outlays of nearly $5.4 billion will be needed in 1981–85 for mining equipment alone, plus $2.1 billion more in 1986–90 to meet increased de-

mand assuming the regional sulfur standards. An additional $923 and $201 million will be needed in 1981–85 and 1986–90, respectively, to comply with the federal 1.2 pound sulfur standards.

Alternative Rates of Demand Growth

The demand growth assumed for the analysis thus far calls for a 30% increase in coal consumption by 1990 over 1973 levels. A second demand growth assumption, a 50% increase by 1990, produces results similar to the 30% growth rate. Each major producing area mined more coal to meet the larger demand, but the impact on the market share of each area varies according to sulfur standard assumption. As evidenced by the data of table 5, southern Appalachia increases its percentage share of the U.S. market dramatically under the higher demand growth rate, especially with the more restrictive sulfur standards. Most of southern Appalachia's gain comes at the expense of northern Appalachia. The West consistently gains in market share with the higher growth rate in demand, although the increases are less dramatic than for southern Appalachia. The West generally expands into markets previously held by the Midwest. The regional impacts of demand growth rate are generally greatest for the Appalachian areas under the regional and 1.2 pound sulfur standards, while the greatest impacts occur under the 3.0 pound and regional sulfur standards for the West and Midwest.

The cost of delivered coal and the amount of coal washed changes only slightly between the two demand assumptions, although the higher growth rate causes a 3% increase in the proportionate share of underground mining and a 28% increase in total capital investment needs.

Conclusions

The results of this analysis indicate that adequate supplies of high-quality minable coal are available within the United States to allow both an increase in coal demand and further tightening of sulfur dioxide emission standards. In short, the coal-mining industry is capable of responding to demands for both energy independence and environmental protection. These goals, however, cannot be reached without complementary response from labor unions, the capital equipment industry, and the transportation industry, nor without some added costs that most certainly will be passed on to the consumer.

Additional costs will be incurred in producing a larger quantity of higher quality coal. This analysis indicates that most of the cost increases to 1990 are associated with increased demand rather than more restrictive sulfur standards. With constant (1973) demand and emission standards approximating current practice (3.0 pound standard), the discounted cost of delivered coal is 24.6¢ per million Btu. A cost increase of 12.9% is suggested to increase demand by 30% from 1973 to 1990. A further cost increase of only 5.5% is needed to change from the 3.0 pound to the regional standards or of 11.4% to change from 3.0 pounds to 1.2 pounds. However, an added increase of only 6.5% is suggested for a change from 3.0 pound standards to a compromise 1.5 pound standard.

Significant changes in the regional location of coal production are suggested with changes in sulfur dioxide emission standards. The Midwest increases production dramatically under the relaxed sulfur standards, while southern Appalachia increases its market share under more restrictive standards. The amount of coal supplied by northern Appalachia changes very little as sulfur standards are varied. Although the West does expand production as sulfur standards are tightened, western coal is never shipped to points east of the Mississippi River.

Increased strip-mining activity is also sug-

Table 5. 1986–90 Percentage of U.S. Market for the Four Major Producing Areas

	Sulfur Standards							
	5.0 Pound		3.0 Pound		Regional		1.2 Pound	
	Demand Growth							
Region	30%	50%	30%	50%	30%	50%	30%	50%
Northern Appalachia	41.2	41.2	41.6	41.4	50.8	42.5	41.6	36.0
Southern Appalachia	2.3	4.7	9.1	16.5	18.4	26.9	36.6	42.6
Midwest	48.9	46.2	40.7	31.9	22.1	18.9	2.4	1.8
West	7.6	7.9	8.6	10.2	8.7	12.5	19.4	19.6

gested, as the amount of coal strip-mined is 86.0%, 81.8%, 73.1%, and 68.8% of total production under 5.0 pound, 3.0 pound, regional, and 1.2 pound sulfur standards, compared with 46.8% in 1973. Although reclamation of strip-mined land would seem to be a more serious problem in the future, the environmental and agricultural impact of increased strip mining could be reduced by more restrictive sulfur dioxide emission standards.

The results of this analysis are generally consistent with other studies of the coal industry, particularly those completed by Schlottman; Nagarvala, Ferrell, and Olver; and the Federal Energy Administration (1976). Although each analysis differs somewhat in approach and input data specifications, most confirm that eastern coal is available to meet much of the demand increase projected for the intermediate term future and that western coal will become a larger and very important, although not exclusive, producer of high quality coal in the longer run.

Finally, this modeling effort must be evaluated with due consideration to the underlying assumptions of the methodology, the problems associated with a large data set, and the level of technology and efficiency included in the model. Some of the more important current and future technologies not incorporated in the analysis include barge and Great Lakes shipping, on-site electricity generation, gasification, and slurry transportation. Also, coal blending was assumed possible, rail transport capacity was assumed unlimited, and metallurgical coal reserves and demand were not separated from steam coal. Thus, further research is needed and underway to analyze the impact of alternative transportation modes and capacities, differential reclamation policies, the social cost of and labor union resistance to displacement of miners from one region to another, disaggregation between steam and metallurgical coal markets, processing technologies, further disaggregation of supply and demand regions, regionalized demand growth projections, export and import balances, and future development of the industry beyond 1990 to the year 2020.

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Response Time and the Location of Emergency Medical Facilities in Rural Areas: A Case Study

S. G. Daberkow and G. A. King

A framework to analyze the delivery of emergency medical care in northern California is proposed. Using a branch and bound algorithm, the most efficient (least-cost) size, number, and location of emergency medical facilities is found subject to a given level of demand and a measure of effectiveness (response time). The current spatial pattern of emergency medical service (EMS) facilities is compared with the most efficient spatial pattern. Due to the sparse distribution of the study area population, some individual EMS facilities are not economically viable given the current revenue structure. Funding alternatives for EMS, including volunteer service, are discussed.

Key words: branch and bound algorithm, emergency medical service, northern California, rural areas.

A goal often espoused for rural development is to reduce the disparities between urban and rural areas in provision of goods and services such as health care and schools (Jones and Gessaman). Since rural areas have small population clusters distributed over a wide area, they may lack economies of scale in facilities found in urban areas. The private sector may be hard pressed to deliver services of high quality due to the costs involved. If public funds are to be used to lower costs, policy makers at all levels of government need information that enables them to allocate resources to reach these goals most efficiently. This study illustrates how economic analysis may assist in the planning process for the delivery of a particular service—emergency medical service (EMS)—in a rural environment.

Objectives

Willemain has presented the goals of an EMS system in terms readily recognizable by economists:

> The goals of the EMS system are to prevent death, disability and suffering in persons with injury or acute illness. The allocation of public resources should be systematically directed to these ends; ideally, the EMS planner should be able to assess the impact of proposed combinations of money, people, facilities and equipment in terms of death, disability and suffering. In other words, the best planning requires input-output relationships linking resource allocations to patient outcomes (p. 4).

Unfortunately, the input-output relationships are not available. Health planners do not currently have available data concerning the effects of various combinations of EMS resources upon the mortality and morbidity of the population under consideration. Thus, this study concentrates on the location of EMS resources rather than the relation between these resources and death, disability, and suffering. The empirical results should be useful to health planners and policy makers who must deal with standards for EMS delivery and the costs associated with those standards.

Two basic assumptions are made: health services should be provided to all persons needing these services, and health services should be provided as efficiently (least-cost) as possible (Cordes). In addition, an EMS system should account for nonresidents in an area, the costs of alternative EMS systems, the size, number, and location of EMS facilities, and a measure of effectiveness.

S. G. Daberkow is an agricultural economist with the Economic Research Service, U.S. Department of Agriculture, and G. A. King is a professor of agricultural economics, University of California, Davis.

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Two standards of effectiveness are response time and service time. Response time is time elapsed from the dispatch of an ambulance and the arrival of an emergency vehicle at the emergency scene. Service time is the time from the dispatch of the ambulance to the arrival of the patient at a hospital. The former standard emphasizes a rapid response of vehicle and trained crew to an emergency situation, whereas the latter standard accentuates the rapid transport of the patient to a more fully equipped hospital emergency room. This study incorporates these standards into the analysis while illustrating the application of a location algorithm (branch and bound programming) that aids in determining the optimal size, number, and location of facilities.[1]

The major objectives of this research are: (*a*) to minimize total costs of providing ambulance service under different standards of effectiveness; (*b*) to determine the trade-off between total costs and different standards of effectiveness; and (*c*) to analyze the financial feasibility of providing EMS as standards of effectiveness and EMS facility usage change.

A specific intent of this case study is to analyze EMS delivery in a rural environment. The study area is the Upper Sacramento Valley of northern California. The sparsely settled mountainous areas surrounding the small- and medium-sized population clusters in the foothills and valley are typical of many rural population distributions.

Operational Model

Background literature on the location of firms and/or agricultural production is quite extensive. The theoretical work of Lefeber, Isard, Kuenne, and Takayama and Judge should be acknowledged as well as a large number of applied studies (see Weinschenck, Henrichsoneyer, and Aldinger). More recent work has involved the use of location algorithms in the public sector (Miller and King; Revelle, Marks, and Liebman). Examples include the work of Hardy, Marshall, and Faris on the placement of medical facilities and Holland and Baritelle on location pattern of schools.

A relatively new class of algorithms, known as tree-searching or combinational programming, can be applied to location problems exhibiting certain characteristics.[2] Typically, these problems minimize only assembly and processing or processing and distribution costs where supply or demand, respectively, is predetermined. These models can be used for locating commodity processing facilities, but their primary use has been with warehouses, hospitals, clinics, schools, airports, transport terminals, police stations, and fire stations (e.g., Chaiken and Larson). If the processing facilities' total cost function is linear with a positive intercept, the problem becomes the classic fixed charges transportation problem (Hadley, p. 136; Scott, p. 128). Such a function implies declining average facility cost.

Additional constraints (such as travel time or distance) are often added to these models to meet various goals defined by a planning body concerned with the provisions of the particular good or service. However, such a system of facilities may no longer be economically self-supporting solely by user fees (i.e., a tax-supported system may be necessary). The reader is referred to Hirsch for a comprehensive discussion of demand and supply aspects of public goods and services.

Algorithms used to solve the above problems range from complete enumeration, such as the Stollsteimer model, to the more systematic examination of a combinatorial tree.[3] The latter approach includes the branch and bound algorithm, backtrack programming, and discrete dynamic programming (see Scott, chap. 2, for an introduction to these techniques). Manne utilizes dynamic programming to solve the location-allocation problem "based on the fact that the total cost of processing and distribution form a hypercube with regard to all possible combinations of locations" (Weinschenck, Henrichsoneyer, and Aldinger, p. 47). This technique is also known as

[1] A reviewer correctly pointed out that the algorithm only considers facility total costs and not declining average costs, which are associated with economies of scale. However, since the facilities are assumed to be uncapacitated (i.e., an ambulance will always be available at a potential facility), the total cost curve is of a long-run nature. This curve is assumed to be linear with a positive intercept; hence, increased usage of a facility implies declining average cost. Size of facility is defined in terms of number of ambulance calls, not in terms of the number of ambulances at that facility.

[2] These problems are sometimes called location-allocation problems. They have the following general structure (Scott, p. 118): "Suppose that there are given (*a*) a set of *n* points distributed in the plane; (*b*) a numerical weight to be attached to each point; and (*c*) a set of *m* indivisible centroids without predetermined locations; then the location-allocation problem in its most general form is to find locations for the *m* centroids and an allocation of each point, or fraction of a point, to some centroid so as to optimize an objective function." In this study, *m*, the number of centroids or facilities, is also part of the solution rather than given.

[3] Integer programming is another alternative, but its application seems limited to small, well-behaved problems.

steepest-ascent-one-point-move algorithm, or SAOPMA. Manne notes, however, that the algorithm may give a local optimum rather than global. An example of backtrack programming used as a location algorithm is not known; however, the solution technique is similar to that of branch and bound programming, which is utilized in this study. All of these techniques can solve very general location problems including those with some nonlinearities. However, their major drawback has been their inability to handle large problems, either because of computer storage requirements or solution times.[4]

This study utilizes a modified branch and bound algorithm to solve the fixed charges transportation problem noted above. The algorithm was proposed by Efroymson and Ray. Khumawala has improved the efficiency of the program. This algorithm was found to be operational for moderately large location problems on the CDC 7600 computer, located at the Lawrence Laboratory, Berkeley, California. (Extensive testing of the capacity and time requirements of the algorithm is reported by Khumawala.) The basic idea is to solve a sequence of linear programming problems (not necessarily meeting the integer restriction) that give progressively improved lower bounds on the value of the objective function of the mixed integer problem. The algorithm terminates when the lowest value for an integer solution is reached.

The mathematical model is as follows:

$$(1) \qquad \min Z = \sum_{i \in N_j} \sum_{j=1}^{n} C_{ij} X_{ij} + \sum_{i=1}^{m} f_i y_i$$

subject to

$$(2) \qquad \sum_{i \in N_j} X_{ij} = 1, \text{ for } j = 1, 2, \ldots, n,$$

$$(3) \qquad 0 \leq \sum_{j \in P_i} X_{ij} \leq n_i y_i, \text{ for } i = 1, 2, \ldots, m,$$

and

$$(4) \qquad y_i = 0, 1, \text{ for } i = 1, 2, \ldots, m,$$

where C_{ij} is the total cost of satisfying the entire demand for EMS services from demand point j from a facility at i (i.e., $C_{ij}=(t_{ij} + \lambda_i)D_j$); t_{ij} is the dollar cost per patient per mile multiplied by miles from i to j; λ_i is the cost per patient that is independent of distance (e.g., linen supplies, equipment use, etc.); D_j is the demand for EMS (ambulance service) at demand point j (patients); X_{ij} is the fraction of the demand at point j that is met by a facility at i; f_i is the fixed charge for establishing and maintaining a facility at i; y_i equals 1 if a facility is established at i and 0 if not; n is the total number of demand points; m is the total number of potential EMS facility sites; P_i is the set of demand points that can be served by a facility at i; n_i is the number of elements in P_i; and N_j is the set of EMS facilities that can serve demand point j. The objective function (equation (1)) indicates the mixed integer nature of the problem, since X_{ij} is continuous and y_i is a binary variable. Equation (2) ensures that total demand at each demand point is exactly satisfied, while equation (3) ensures that a facility i is open before it can serve demand point j.

Demand and Cost Estimates

One of the primary objectives of EMS health planners is to account for resident and also nonresident need for such services. Jeffers, Bognanno, and Bartlet define need as "that quantity of medical services which expert medical opinion believes ought to be consumed over a relevant time period in order for its members to remain or become as 'healthy' as is permitted by existing medical knowledge" (p. 46).

Economists tend to consider demand for goods and services as being a function of prices and income. Thus, demand is usually constrained to a greater extent than is need. However, in true life-threatening situations where medical attention is not postponable, the influences of prices and ability to pay diminish. Emergency ambulance service is considered to be price and income inelastic, and the aggregate demand for such services is related to such variables as population, type of occupation, and the like.

Measures of need and demand are difficult to obtain. For example, the medical profession does not give an unequivocal definition of need that can be translated into an operational standard for response time. Further, available data are for actual usage that may be

[4] Another category of solution algorithms, not discussed here, is known as heuristic methods and defined as (Scott, p. 39): "algorithms [that] represent sets of rules which produce solutions to given problems, but which do not necessarily produce the best possible solutions." The interested reader should consult the bibliography of Scott. A recent example of such an algorithm in the *Journal* is given by Hardy and Grissom.

influenced by availability of services rather than a pure demand or need concept. Also, the data generally reflect total ambulance services including both emergency and nonemergency calls. Discretionary use of ambulance services such as routine transfers is most likely influenced by price, income, or type of insurance coverage. Previous studies, such as by Aldrich, Hisserich, and Lave, have found some price elasticity in the demand for ambulance services, but this may reflect nonemergency response.

Annual and Peak Month Demands

The "demand" for ambulance services by the residential population was estimated to be 29.5 calls per 1,000 population per year. This estimate, which includes emergency as well as nonemergency calls (t-value = 14.8), is based on regression analysis using data from the California Department of Transportation's *1968 Ambulance Survey* of thirty-six counties with less than 125,000 population (a comparable figure based on an analysis of all counties in California is 48.5 calls per 1,000 population, which apparently reflects the higher urban use pattern). The counties with less than 125,000 were assumed to represent the demand conditions of California's rural counties.

Northern California experiences a large seasonal influx of tourists, sportsmen, campers, and others seeking outdoor recreation. In addition, Interstate 5 serves as a major transportation artery for west coast travel, adding transients to the potential demand for emergency services. Data on transient population were estimated for all major highways in the area based on reports of traffic flow published by the California Business and Transportation Agency. Recreation use data are available from the U.S. Forest Service, California State Parks and Recreation Department, U.S. Department of Interior, the National Park Service, and the Pacific Gas and Electric Company (see Daberkow for data sources). Private recreation sites are not included, but second home tracts in U.S. forests are included.

The above annual demand estimates are expressed in terms of calls per resident. Some of these calls may have been by nonresidents, and therefore the number of calls on a per resident basis may be overstated. The transient population estimates derived from the above sources are utilized to give a demand for EMS based on resident plus nonresident population. Transients, by definition, are in or near a given point for a short (less than a year) time. Therefore, estimates are expressed in terms of visitor-days on a monthly basis for various points throughout the study area. Combining visitor-days with resident-days gives population-days, which is one indication of the monthly distribution of population concentration at selected points.[5] August is the peak concentration month for this area. Regression analysis, using counties as observation units, reveals an estimate of 0.435 ambulance calls per 1,000 population-days.

Demand Points and Potential Facility Sites

The study area population, which is dispersed over approximately 13,000 square miles, is represented by seventy-two demand points (see figure 1). The decision for inclusion of nineteen of the seventy-two demand points was clear cut. The population of these cities, reported by the 1970 census, ranges from 1,115 to 32,818 (U.S. Dep. Commerce). The population for enumeration districts nearby these cities is also represented by that demand point. In aggregate, these nineteen demand points include 81% of the study area population. Selection of fifty-three other points was based on two other sources of information—the California Division of Highways listing of rural and urban places by population category and the U.S. Post Office listing of zip code areas.

The demand points used in this study, therefore, represent a wide range of population distributions within varying geographic shapes. The geographic areas represented by the demand points vary in size (i.e., square miles), population, and concentration of population about the point.[6]

Thirty-two of the seventy-two demand points were selected for potential facility loca-

[5] A visitor-day is defined as one visitor at a particular site for twelve hours. A resident-day equals two visitor-days, since a resident is assumed to remain near a given point for twenty-four hours per day.

[6] Density (people per square mile) is not an adequate measure of the population distribution. For example, a large population cluster in a large area may have the same density as a small area with a small population. However, if the former area has its population concentrated near the demand point whereas the latter population is scattered, population density is a poor index of dispersion. A more desirable variable is the proportion of population within, say, a mile radius of the demand point. For nineteen cities, about 71% of the assigned population is within the city limits. No such information is known for the other demand points, since reliable census data are available only for places and cities larger than 1,500 population.

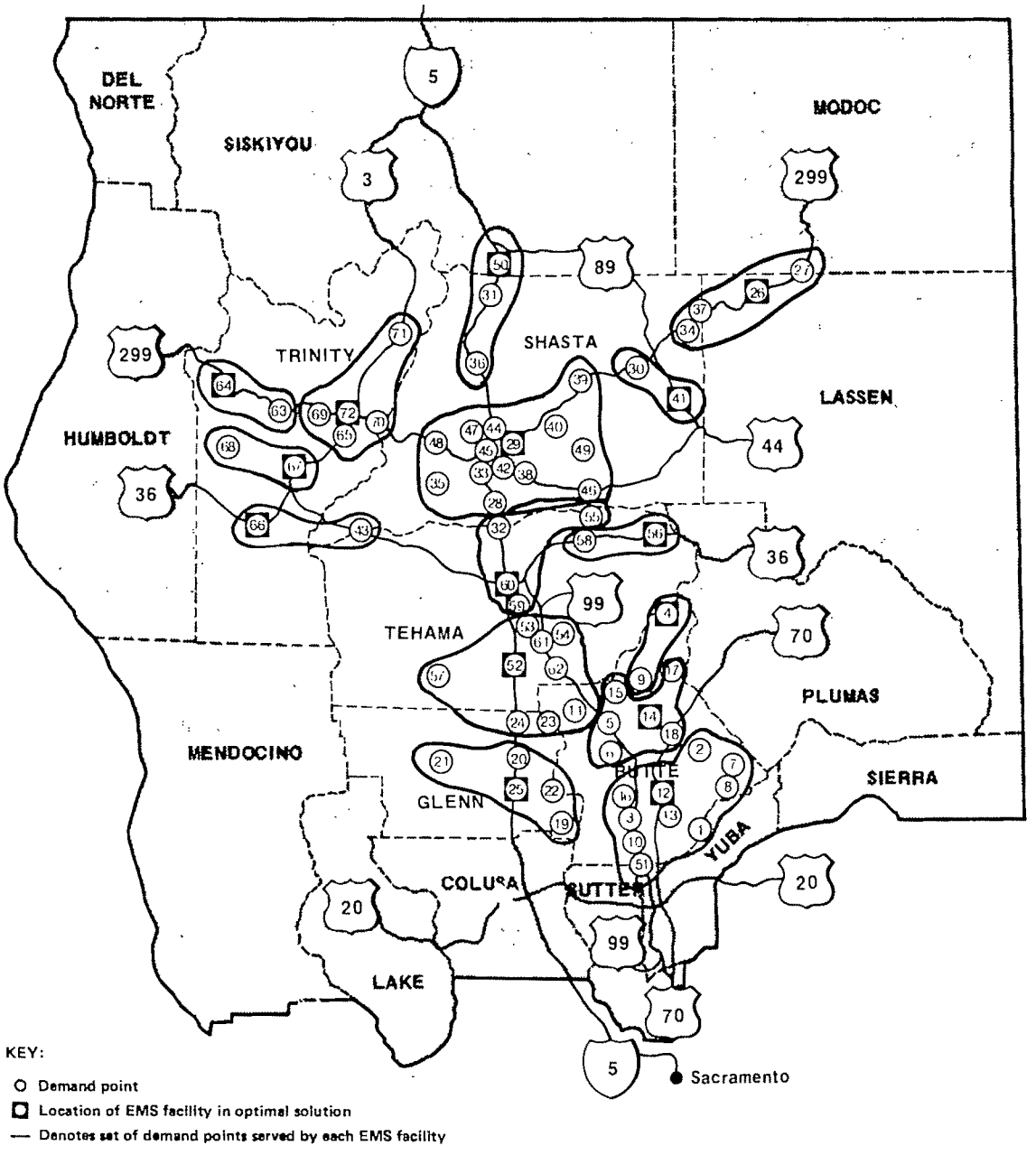


Figure 1. Facilities and demand points associated with those facilities using the forty-minute response time standard (optimal system)

tions. These sites were selected on the basis of two general guidelines. First, fifteen cities currently served by an EMS facility are included. The remaining seventeen potential sites were selected by inspection of the spatial dispersion of demand points and the associated travel time to existing facilities. In these more remote areas, a point could be designated a potential facility site regardless of its population size in order to meet the largest response time standard (i.e., one hour).

EMS Cost Function

The basis of cost estimates for ambulances is the National Highway Safety Bureau report by Dunlop and Associates. This points out the high costs of providing quality emergency

services for rural areas that generate relatively few calls and require long travel times. Many rural areas have responded to these high costs by initiating a lower quality volunteer EMS facility, lowering per call costs. Since population density varies widely in the study area, average costs per call also are expected to vary accordingly even with a volunteer EMS facility.

The question of economies of scale essentially refers to a planning curve for facilities of varying designed capacity, i.e., one, two, or more ambulances per facility. For the study area, the one ambulance facility appears feasible due to the low demand for ambulance calls.[7] However, the nature of fixed cost for the facility must be considered. It has two aspects. The first is the conventional aspect that French, Sammet, and Bressler describe as "fixed base (that) represents the long-run average rate of return above variable costs that are required to maintain and replace the capital goods" (p. 572). Capital goods would be the ambulance and related facilities. The second aspect of "fixed cost" for a twenty-four-hour ambulance facility is the crew needed if the facility is opened. Of course, a volunteer crew requires a substantially smaller "fixed cost" outlay.

The annual cost function for a full-time EMS crew and facility is based on an update of the Dunlap and Associates study. The estimated cost of a fully staffed, twenty-four-hour per day ambulance service is $70,000 plus $10 per call plus 10¢ per mile of response distance. The $10 per call reflects variable costs (e.g., oxygen, splints, linens, etc.) independent of fixed costs. Fixed costs are much lower for a volunteer EMS crew. For this study, the annual costs of a volunteer facility are estimated to be $6,500 (fixed cost) plus $10 per call (variable costs) plus 10¢ per mile of response distance.

[7] This model implicitly assumes an ambulance will always be available at a potential facility, thereby neglecting probabilistic aspects of ambulance call arrival rates and ambulance service times. Using queuing theory notation, this implies an M/M/∞ or M/G/∞ system (Wagner, pp. 865–66). The facilities are commonly assumed to be uncapacitated, and a postoptimization analysis determines the number of ambulances necessary at each facility to keep expected response time below a given standard. (See Bell and Allen for a discussion of the number of ambulances necessary at a given location.) An M/G/∞ queuing model, for a one-ambulance facility servicing 2,012 calls per year (the largest number reported in this study), using a mean monthly arrival rate and having a one-hour average service time, would exhibit a probability of 0.19 for a call having to wait.

Location of Facilities

Currently, there are fifteen EMS locations serving the area. The present system is compared with optimal locations for given levels of demand and response and service time standards. Response time refers to the time between the notification of an emergency and the arrival of an ambulance at the scene. Emphasis is given to the trade-off in total costs and percentage of population served as the response time standard is increased from thirteen minutes, a standard often promulgated for an urban area by health planners, to sixty-seven minutes.[8] The latter is considered an upper limit to effective response time.

Response Time Standards

Given the present system with fifteen EMS facilities and a thirteen-minute response time, forty-two of the seventy-two demand points cannot be served within that time standard.[9] These points represent about 25% of the population of the entire area. As the time standard is increased by increments of approximately thirteen minutes, the number of sites needed is reduced until, at a sixty-seven minute response time, only eight sites could serve the entire population at a cost of about 57% of that for the simulated thirteen-minute situation. Results for these and other response times are shown in table 1 for the present system.

An optimal location of facilities under these same response time standards and demand conditions is also given in table 1. To meet the thirteen-minute standard, EMS facilities would have to be located at thirty-one of the thirty-two potential sites (see table 1). However, twenty-two demand points still would not be served under this time constraint, or about 14% of the area population. One should note that, in order to serve 100% of the population within thirteen minutes, more than thirty-two facility sites are required.

[8] The response times were selected to correspond to the time an ambulance traveling an average of 45 miles per hour would require to travel 10, 20, 30, 40, and 50 miles, respectively.

[9] The algorithm requires that all demand points be served within at least sixty-seven minutes. When a smaller response time is imposed, not all demand points can be reached within that time. Of course, all demand points could be served within a given time standard if an EMS facility could be established at each demand point. However, this was fiscally infeasible; therefore, only thirty-two of the demand points were allowed to be potential facility sites.

Table 1. Response Time Standards: Comparison of Selected Parameters for the Optimal and Present Location Patterns of EMS Facilities (Annual Demand)

Response Time Standard (Minutes)	Number of Facilities	Total Annual Cost (Mil. $)	Demand Points Not Served	Percentage of Total Population Served
		Optimal System		
13	31	2.244	22	86.2
27	22	1.615	11	97.7
40	15	1.129	1	99.8
53	9	0.709	0	100.0
67	8	0.640	0	100.0
		Present System		
13	15	1.125	42	75.1
27	14	1.055	21	95.5
40	12	0.916	9	98.4
53	9	0.707	1	99.9
67	8	0.641	0	100.0

The trade-off between response time standards and system cost is shown in figure 2, where costs drop sharply as the number of facilities decrease and response time increases. The percentage of the population served, however, increases with decreases in response time. For a thirteen-minute response, 86% of the population is served, but for a twenty-seven minute response time with twenty-two facilities, about 98% of the population is served. The location pattern of EMS facilities and demand points served by those facilities for the forty-minute response time is given in figure 1.

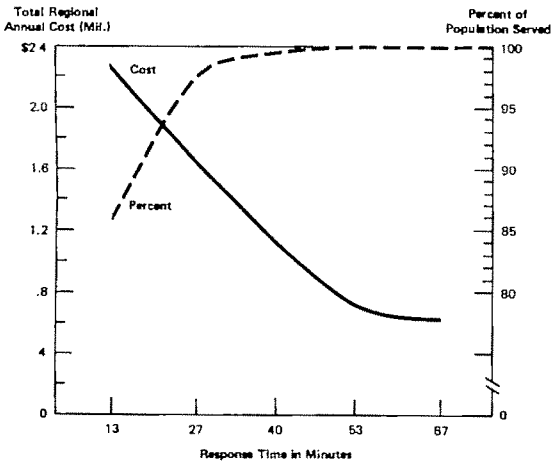


Figure 2. Relation between response time, total regional cost, and percentage of population served within various response times

The standards promulgated in the 1974 California state plan for Emergency Medical Services delivery suggest that 90% of the population for low density areas should be within thirty minutes of an EMS facility (California State Dep. Health). The twenty-seven-minute response time standard meets these criteria. The total cost of this system is $1.6 million. However, this system does not account for nonresident needs, which are discussed next.

Peak EMS demand occurs during the summer months, particularly in August. If the goal of the EMS system is to locate permanent facilities to meet the peak month demand of residents and nonresidents at minimum cost, the analysis must be modified. The approach is to estimate the number of population-days for transient population associated with the various demand points based on estimated traffic flows and visits to parks and forests. Demand for EMS is assumed to be a function of the number of population-days at each demand point.

The resulting location of facilities did not change substantially from that given previously. The annual costs are slightly higher due to travel costs for more patients. Also, there are slight reductions in the percentage of population served with given response time standards. This is due to the use of remote recreation areas by nonresidents.

Service Time Standards

Service time is defined as the total time between notification of an accident and delivery of the patient to the nearest hospital. Service standards are set at twice the corresponding response time standards to evaluate the trade-off between costs and service time. Since the general results are similar to those presented for response time, these will not, in the interest of brevity, be presented. There are differences, however, in the location of facilities for the service and response time standards. Given locations of hospitals, the service time model locates EMS facilities so as to minimize backtracking. Figure 1 indicates the location (numbers in parentheses) of the following study area hospitals: Chico (5), Paradise (14), Oroville (12), Gridley (10), Willows (25), Redding (45), Fall River Mills (34), Red Bluff (60), Corning (52), and Weaverville (72).

Financial Feasibility of Individual Facilities

The previous analysis provides aggregate costs of a regionwide EMS system with given response and service time standards. To answer the question of the economic feasibility of the individual facilities, the forty-minute response time model with annual resident demand is selected. (Other response times can be analyzed similarly; however, the forty-minute response time adequately illustrates the economic concepts.) Here, fifteen sites are found in the optimal solution. We have shown how costs vary under different response times, so costs and revenues for each facility are developed next.

Health planning officials indicate that private ambulance operations in the study area commonly charge a basic amount per call, a mileage rate, and a charge of incidentals (e.g., linens, bandages, oxygen, splints, resuscitator, etc.). The charges used in this analysis are \$45 per call, \$10 for incidentals, and \$2 per mile between demand point and hospital. No distinction is made between patient transfers and emergency calls. It is assumed that the total charge is collected from 80% of the calls, since there is evidence that full payment in all cases is a rarity (California Dep. Transportation, p. 132).

The economic feasibility of the fifteen facilities, shown in table 2, varies directly with the number of calls serviced by the facility. Only in the first facility, serving a population of 68,511, does average revenue exceed average cost. Deficits are substantial for low density sites.

The average cost per resident of the entire study area is \$4.63 per year for providing this service. If the revenue generated by the system is considered, the average cost per resident would be \$3.06 to provide a break-even system. Whereas the first-listed region more than breaks even, costs exceed revenues for the other fourteen locations, and the charges are prohibitive for the low density areas.

One alternative is to consider a volunteer system similar to rural fire departments. This method would eliminate labor costs (i.e., no full-time drivers or attendants and clerical staff); the rent, phone, and utilities are assumed one-half of the fully staffed facility; but insurance and depreciation are equal for both systems. Annual fixed costs for the volunteer system are \$6,500 as compared with \$70,000. The revenue for the volunteer system is reduced to \$20 per call plus \$2 per mile from the demand point to the nearest hospital, with charges 80% collectible. This method was evaluated for facilities showing less than 400

Table 2. Financial Analysis of Facilities Entering Optimal Program with Forty-Minute Response Time, Resident Population Only

Facility Site	Fully Staffed Facility (24 Hours per Day)					Volunteer Facility for < 400 Calls per Year	
				Cost per Resident		Cost per Resident	
	Total Calls	Cost/ Call	Revenue/ Call	Average	Net	Average	Net
				\$			
29 Redding[a]	2,012	46	54	1.36	−0.23	[b]	[b]
14 Paradise[a]	1,841	49	48	1.45	0.05	[b]	[b]
12 Oroville[a]	1,266	66	49	1.94	0.51	[b]	[b]
52 Corning[a]	614	125	59	3.66	1.94	[b]	[b]
60 Red Bluff[a]	581	129	51	3.79	2.31	[b]	[b]
25 Willows	292	250	54	7.34	5.77	0.82	0.06
50 Dunsmuir[a]	116	614	64	17.88	16.02	1.79	0.75
26 Bieber[a]	109	654	64	19.15	17.28	1.94	0.89
72 Weaverville[a]	107	665	60	19.09	17.38	1.91	1.01
41 Old Station	96	741	78	21.67	19.39	2.19	0.72
67 Hayfork[a]	60	1,177	102	34.54	31.56	3.35	1.18
64 Burnt Ranch	29	2,424	98	69.00	66.21	6.54	4.55
4 Butte Meadows	19	3,695	90	107.02	104.40	10.08	8.27
56 Mineral	12	5,845	84	153.81	151.60	14.43	12.95
66 Forest Glen	9	7,789	121	204.97	201.79	19.16	16.72
Study area	7,163	158	53	4.63	3.06	2.01	0.54

[a] Indicates cities that currently either have commercial or volunteer ambulance services.
[b] Facilities with greater than 400 calls per year where costs equal those shown in columns to the left.

calls per year or slightly more than one call per day.

The financial feasibility of the combined fully staffed facility (greater than 400 calls) and a volunteer system (less than 400 calls) is improved considerably as shown in the last two columns of table 2. If the cost of the system is shared equally by residents of the area, it drops from $4.63 to $2.01 per resident; if revenues are added, the deficit drops from $3.06 to $0.54 per resident. The question still remains as to whether residents of a break-even area would be willing to be assessed to cover deficit, volunteer-force areas.

Funding Alternatives

A feature of emergency health service is that its availability is important not only to residents but to transients as well. Even for the resident population, there is no assurance that an accident or acute illness will occur within the service area of an established EMS facility. The questions then center on deciding the response time standard, the quality of this service (full facility versus volunteer service), and the allocation of costs of these services.

If health planners or policy makers conclude that the current spatial pattern of EMS facilities is inadequate, what will be the fiscal outcome? The question can be analyzed by comparing the "present system" with the "optimal system" presented in table 2. An analysis of the financial feasibility of the "present system" EMS locations (for the forty-minute response time standard), using the cost and revenue structures given above, indicates that only one of twelve locations can break even with a twenty-four-hour fully staffed facility. The difference between revenue and cost per resident with present location facilities ranges from −$0.28 to $43.47, compared with −$0.23 to $201.79 for fully staffed optimally located facilities as shown in table 2. Clearly, quality specification in our model is above that found in current facilities. But an interesting question is: If health planning agencies specify a given response standard, who is to pay the cost? The findings indicate that private purveyors would find it unprofitable except in heavily populated areas or where ambulance services are a secondary activity. The latter is the case in this study area, but detailed analysis of these businesses is beyond the scope of this study.

Funding alternatives to maintain a high quality EMS system include:[10] (*a*) increases in charges by private purveyors, but this alternative appears infeasible for most areas;[11] (*b*) direct or indirect subsidies to operators; (*c*) public operation of services; and (*d*) grants by state or federal agencies.

Subsidy schemes can originate at the local, regional, state, or federal level. An example of an indirect subsidy is where a regional regulatory board creates a spatial monopoly for an EMS purveyor—a common arrangement for some ambulance services. The model used in this study essentially traces out such spatial boundaries, and if only one purveyor operates in each area, it has a spatial monopoly. Thus, franchising, exclusive contracts, and zoning allow EMS purveyors to increase the number of calls and achieve lower average costs.

Direct subsidies at the local level might include use of local tax revenues to reimburse purveyors for noncollectible charges, dry runs, or indigent patients not covered by Medicare or Medicaid. The level of annual subsidy for the sparsely used facility (see table 2) is over $69,000 per year. Some of these service areas cross county lines, however, and regional funding might result in more efficient delivery of services.

Regional operation of EMS facilities might be organized similar to a cooperative. Facilities could be privately or publicly owned. Public finance literature contains a wealth of examples where goods and services are provided by the public rather than the private sector (see Musgrave and Musgrave). Funding might be provided by a multicounty tax district to subsidize losses for the entire system.

Subsidies using state or federal tax funds differ in an important respect in that residents and nonresidents would provide source of funding. Due to the possible use of facilities by nonresidents, this approach has some merit. Here, the user or immediate potential user

[10] The use of prepaid EMS is another possibility. There are two problems here: (*a*) the costs would be prohibitive unless funding is on a regional basis, and low density areas would be subsidized by high density areas; and (*b*) since EMS is rarely denied anyone in need of emergency care, a "free rider" problem develops. One reviewer noted that demand may be affected with this type of financial mechanism. The simultaneous nature of demand, location, and type of payment is acknowledged, but the investigation of this system was beyond the scope of this study. This question is also commonly debated with regard to the issue of national health insurance.

[11] Although the model assumes perfectly inelastic demand, this assumption is realistic only over some price range. At some price, the demand for EMS would apparently have a positive slope.

does not pay the full cost of the service. State funding could be provided from the sales tax, which is returned to cities and counties from which it is collected. Again, the sparsely populated counties would probably have strong demands on any such limited funds that would be available from this source.

Grants are another source of funding. Federal and state agencies as well as some private foundations have been willing to provide EMS equipment or funds to purchase ambulances and communication equipment. Regional Medical Programs, Robert Wood Johnson Foundation, Cranston Funds (PL 93-154), and the California Office of Traffic Safety are examples of such funding sources. Grants of equipment should be considered annual grants over the depreciated life of the equipment. At the end of that time a similar subsidy must be obtained or a depreciation reserve accumulated in order to continue the service.

Summary and Conclusions

The current debates on provision of medical services in general and emergency services in rural areas in particular appear to suffer from a lack of economic analysis. Using the EMS goals and standards set out by the state of California to serve rural and semirural areas, this study provides a framework under which policy analysis can proceed more rationally. EMS facilities that comply with response time standards, similar to those of urban areas, were prohibitively costly in the rural parts of the study area. Increasing the response time standards reduced the regional cost of the EMS systems and allowed some of the individual EMS facilities to become economically viable, since additional people could be served by each facility. The trade-off between cost and various response time standards was a key part of the analysis. A by-product of the regional cost estimate was the most efficient (least-cost) spatial pattern of EMS facilities for the study area.

There are important gaps in the analysis. The question of trade-offs in response time and system cost are but a first step. Medical input is needed to provide the loss function associated with delays in response to various types of accidents. We consider only ground ambulance service, whereas remote areas could also be served by helicopters. (See Plaas et al. for bibliography of studies on alternative transport systems.) The analysis does not consider multiple accidents and the need for back-up facilities in some areas, which is primarily a queuing problem.

This framework will be useful to regional medical planning groups. Of particular interest are the high costs involved in providing services to remote areas. The use of volunteer services would appear to be a necessary condition for persons selecting nonurban living environments. Sources for financing such services must be viewed in a broader context of local, state, and federal tax structures. Recommendations on funding of a particular service, such as EMS, would be presumptive without analysis of all demands on a rural economy. However, if the goal is to obtain efficiency in the delivery of services, major categories should be analyzed on a broad enough regional basis to allow consideration of reorganization of such services on an efficient basis. Particular attention should be paid to the relation between planning goals or standards and the associated costs. This study approach should be of use in analyzing delivery systems for several other services in rural areas.

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Rent Extraction and the Survival of the Agricultural Production Cooperative

Andrew McGregor

During the last twenty years there has been a proliferation of production cooperatives in the agricultural sector of low income countries. This paper examines the prospects for this type of firm in light of their poor historical record. A theoretical model is presented that shows the extraction of scarcity rents is a necessary condition for survival. Several case studies examined are found to be empirically consistent with the model. It is shown that policies can be devised for the extraction of rents.

Key words: New Guinea, paradox of success, Peru, plywood cooperatives, production cooperatives, rent.

For this paper, a production cooperative is defined as a self-managed association for the purposes of production. The members must work in the enterprise and manage it according to democratic principles. This analysis excludes utopian communal societies operating outside the economic mainstream and also excludes enterprises like the Soviet Sovkhozy and Kolkhoz.[1] In addition, this production cooperative differs fundamentally from the conventional agricultural marketing cooperative. (A marketing cooperative may be involved in production in the sense that it processes the product of its members. Yet, the members perform their producer role outside the cooperative.)

Today production cooperatives are most significant in the agricultural sector of low-income countries. It is here that the findings of this paper are of greatest practical relevance. Since World War II, the circumstances of agricultural production cooperatives have been numerous and varied. Governments have sometimes promoted them as replacements for existing institutions that have failed to meet their development objectives. For example, as part of the 1969 Peruvian agrarian reform, the large sugar haciendas were converted to cooperatives.[2] A similar pattern was observed in Chile during the Allende era. In both Yugoslavia and Algeria, state farms have been reconstituted as cooperatives. Tanzania has adapted the production cooperative to the traditional village structure in the form of the Ujamaa village. In some instances production cooperatives have been promoted as a means of opening up new agricultural land. The Israel kibbutzim, in part, fit this category. A number of settlement schemes in the South Pacific have involved production cooperatives. On occasions agricultural producer cooperatives have evolved spontaneously with little or no government involvement. A number of cooperative plantations in New Guinea are examples.

The production cooperative is not a new phenomenon. Industrial production cooperatives were numerous in nineteenth century Britain and France. Significantly, the attrition rate for these cooperatives was such that they had all but disappeared by the First World War.[3] The majority of the nineteenth century cooperatives failed for financial reasons. The

Andrew McGregor is a lecturer in economics at Wollongong University, Australia, and is currently completing his Ph.D. at Cornell University.

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[1] The Sovkhozy are state-operated farms employing wage-earning employees. The Kolkhoz are peasant collectives, yet they cannot be regarded as self-managed associations. The chairman of the Kolkhoz is a government appointee. Further, most major production decisions come from outside the firm (Nove, p. 47).

[2] Initially, the sugar haciendas together with the coastal agroindustrial complexes were converted to cooperatives in name only. Management committees were dominated by government representatives. Further, the minority worker representative was elected in an undemocratic fashion. In April 1972 the system was radically changed. Management was placed exclusively in the hands of democratically elected workers (Gouverneur, pp. 199–202; Horton, pp. 60–64; Vanek 1973).

[3] An indication of the attrition rate is that of the 253 production cooperatives created in Britain between 1862 and 1880 only 28 still existed as cooperatives in 1892 (Jones, p. 115).

contributing factors included inadequate legal status and protection, poor management, and insufficient capital.[4] Further, British cooperatives in the latter part of the nineteenth century were adversely affected by trade union hostility. Yet, not all producer cooperatives were financial failures.[5] Paradoxically, the survival rate for the financial successes was no better than for the financial failures.

It is this apparent "paradox of success" that causes the most concern when appraising the potential of production cooperatives. It suggests that in the long run a production cooperative will not survive irrespective of legal status, quality of management, and social environment. An explanation of this paradox is presented. I will argue that a production cooperative can survive, but only if scarcity rents are paid to nonlabor resources.

The Nonpayment of Scarcity Rents by Production Cooperatives

Historically, production cooperatives have not paid scarcity rents to capital because of internal financing. Establishment capital was obtained, through both necessity and desire, from the collective contributions of members.[6] They were subsequently financed through retained earnings. The foregoing of the capital market precluded the necessity to make any payment to capital. (Unlike many consumer and marketing associations, production cooperatives have rarely made any payments to internally raised capital.[7])

Substantial internal financing is a feature of agricultural firms even in the most highly industrialized economy. An agricultural production cooperative without sizable government assistance is unlikely to be an exception. Unfortunately, when assistance has been forthcoming, it has been in the form of land grants, accentuating the problem of rent extraction. (The cooperative receives free, or at minimal cost, a resource that makes a major contribution to its members' income.) The Peruvian sugar cooperatives provide an excellent example of this occurrence (Horton, pp. 57–66). A plantation examined in the paper is another such case.

Theoretical Implications of Not Paying Scarcity Rents

The following theoretical discussion draws on the work of Domar, Ward, and in particular Vanek (1975). The model is similar to those developed for marketing cooperatives in the sense the firm's objective is to maximize the surplus per unit of patronage (Helmberger and Hoos, Helmberger, Youde and Helmberger). Yet, the nature of patronage for a production cooperative (labor input) makes the model fundamentally different.

Consider this simple model of an agricultural production cooperative. As a typical agricultural firm, it is a price taker operating under constant returns to scale. The members supply all the cooperative's labor. Their objective is to maximize income per worker. Formally, this can be stated as

$$y = (P_x X - P_z Z - P_v V)/L, \tag{1}$$

where y is the income per member, P_x is the product price, X is the output, P_z is the rents paid to capital and land, Z is the quantity of capital and land, P_v is the price of nonlabor variable inputs, V is the quantity of nonlabor variable inputs, and L is the number of workers. Assume that this cooperative is exclu-

[4] In Britain before 1864 it was illegal for cooperatives to sell to anyone but their own members. Each member was defined as a partner and as such could "pledge the cooperative's goods and credit and take its money without any effective remedy" (Jones, p. 121). Without the protection of limited liability, it was difficult to attract new members. Regardless of the size of his shareholding, each member was under unlimited liability to pay creditors if the association defaulted.

[5] In nineteenth century Britain, Jones reports very successful cooperatives in the textile and shoemaking industry (pp. 260–61, 402–16). The same can be said for the precision instrument cooperatives in France (Digby, p. 69; Willson, p. 26). In the United States, plywood cooperatives established just after the First World War have been among the most successful firms in the industry.

[6] The cooperative was often the product of a strike or a lockout, leaving banks and other lending institutions unfavorably disposed to them. The desire for internal financing resulted from the assumption that asset ownership was a necessary condition for enterprise control.

[7] Most marketing and consumer cooperatives trace their origins to the Rochdale Pioneers. The Pioneers and their adherents argued that while capital should not be the claimant of any surplus it should be paid the market rate of interest. Rochdale cooperatives, in varying degrees, have satisfied this maxim by paying dividends in accordance with members' individual capital contributions. Historically, production cooperatives have not been a part of the Rochdale movement and have generally not adopted this procedure. The decision not to make payments to internally raised capital has often had an ideological basis. In this respect the influence of the nineteenth century French intellectual Phillipe Buchez was most significant. (Buchez is generally regarded as the "father" of self-managed production associations.) A fundamental tenet of the Buchezian philosophy is that the capital of a cooperative should be "social, inalienable, and indivisible" and that members be paid only in accordance with their work (Reibel, p. 40). In some more recent situations, Marxist ideology has tended to preclude interest payments to capital (the Yugoslav firm provides an example).

sively internally financed and that it received its land as a government grant. As a consequence, it pays no capital or land rents, and equation (1) is reduced to

$$(2) \qquad y = (P_x X - P_v V)/L.$$

Given equation (2), y always increases with the average product of labor (X/L). Thus, with X/L inversely related to L, for any given quantity of land and capital, it always pays the cooperative to reduce its membership. Consequently, it never replaces a member who retires or dies unless the new member contributes sufficient capital to increase X/L. This incentive to reduce membership is the result of capital and land rents not being separated from labor income in the determination of y; it pays to share any given level of rents among as few workers as possible.

If L decreases, so does, *ceteris paribus*, the marginal productivity of capital and land; the capital-labor and land-labor ratios increase. The effect of this is an incentive to disinvest; the returns from capital and land are now less than what was previously desirable. An agricultural firm can disinvest in a number of ways. Soil conservation practices can be reduced, maintenance of irrigation canals can be neglected, the rate of replacement of tree crops can be reduced, etc. Any restoration of the desired rate of return is purely transitory, for the incentive to reduce working membership always remains.

Coupled with a tendency to disinvest a propensity to underinvest may exist. (Underinvestment occurs when the rate of return exceeds the decision maker's rate of time preference.) Conventional investment theory maintains that a rational individual invests until the rates of return (A) and time preference (R) are equated. Implicit in this theory is the expectation that the invested principal is recouped at the end of the investment period.[8] For production cooperatives retained earnings tend to be regarded as the collective property of the membership, an individual benefiting from a collective investment entirely through increased y. Thus, individuals do not have the expectation of recouping any of the collectively invested principal.[9] Hence, an individual requires A to be higher than R to make an investment worthwhile. Formally, he is willing to invest if

$$(3) \qquad A \geq R + E \text{ for } E \geq 0.$$

The factor E is compensation for nonrecouped principal. It is a variable that increases at an increasing rate as the member approaches retirement. For a young worker the dimensions of E are trivial, but for a worker near retirement the rates of return have to be immense to justify an investment.[10]

If the age structure of the cooperative is stable, the propensity of the firm to underinvest remains constant. Yet a stable age structure is highly unlikely. If, as hypothesized, members who leave the cooperative are not replaced, the working collective gets "older" through time. The result is an increasing tendency of the cooperative to underinvest.

In the realistic event that the cooperative has a pension scheme for its members, the dimensions of E are modified. The most effective scheme in this respect is one that fixes the pension rate in a given year to the prevailing y. (A member has a financial interest in the post-

[8] If the invested principal is recouped, the present value of an invested dollar is given by

$$V = A \sum_{i=1}^{T} (1 + R)^{-i} + (1 + R)^{-T},$$

where V is the present value of the returns from the invested dollar, A is the annual returns from the invested dollar, R is the rate of time preference, i is the ith time period of the investment, and T is the total investment period. An extra dollar is invested until $V = 1$; at that point $A = R$. Consider the following empirical vertification: if $R = 6\%$, and $T = 2$, then when

$$A \sum_{i=1}^{2} (1.06)^{-i} + (1.06)^{-2} = 1,$$

$A = 0.1100/1.8334 = 0.06$.

[9] Marketing cooperatives sometimes use a revolving fund to return invested principal to individual members. (This involves issuing stock to members when earnings are retained and redeeming this stock after a fixed time period. Kohls [p. 236] reports that 61% of U.S. marketing cooperatives use this technique.) I know no case of a production cooperative using a similar technique. For some production cooperatives, the return of collectively contributed capital to individual members would be ideologically objectionable. (A basic Buchezian principle is that capital must be the permanent "social" property of the association.)

[10] If the invested principal is not recouped, the present value of a dollar invested is given by

$$V' = A \sum_{i=1}^{T} (1 + R)^{-i}.$$

Consider a young member who expects to work in the cooperative for another thirty years (assume $R = 6\%$). He would be willing to invest a dollar if

$$A \sum_{i=1}^{30} (1.06)^{-i} \geq 1;$$

i.e., $A \geq 7.2\%$. This represents an E factor of 1.2%. Take the same member two years before retirement. He would now be willing to invest a dollar if

$$A \sum_{i=1}^{2} (1.06)^{-i} \geq 1;$$

i.e., $A \geq 54.5\%$. The E factor has increased to a huge 48.5%.

retirement returns from an investment.) Yet, even if pensions are a high percentage of y, the magnitude of E is still likely to be higher for a member approaching retirement.[11]

Collective investment coupled with an "aging" membership provides a strong financial incentive to sell the cooperative within a working generation. After a period of some forty years, most, if not all, members will be close to retirement. Over this period they have collectively built up considerable equity in the cooperative. Thus, near retirement all members have a strong vested interest in selling the firm and distributing the receipts amongst themselves.

An initial assumption of the model is that the cooperative only employs member workers. This assumption, while consistent with cooperative ideology, is inconsistent with members' economic self-interest. It always pays to employ nonmembers if their fixed wage is less than the income per head (hired labor's contribution to total production always exceeds the cooperative's wages bill). This is illustrated in figure 1. (For simplicity, it is assumed that labor is the only variable input.) Suppose that initially the members supply om labor and no outside labor is employed, then income per head (y) is mf/om—the average product of labor. Suppose also that outside labor is hired at a wage given by the slope of line P_L. Income per head is maximized by hiring mb labor; at b the marginal product of labor (X_L) is equated to its price. The additional labor adds cd to revenue product at a cost in wages of only de; y has been increased by ec/om.

The incentive to reduce membership is independent of the employment of nonmembers. The cooperative depicted in figure 1 would reach an equilibrium of one member and $ob - 1$ employees. Clearly, the closer the firm is to this equilibrium, the less it resembles a cooperative.

It is the forces pushing the cooperative toward equilibrium, and not the equilibrium itself, that are important. In reality, an equilibrium of one working member is unlikely to be ever reached. The cooperative may be sold, if law permits, well before this point. Alternatively, underinvestment may lead to financial failure and liquidation. In other circumstances, equilibrium membership may be somewhat greater than one. The cooperative may pay a small portion of the scarcity rent of capital and land. (Land may not be a government outright grant.) This, as will later be shown, eventually halts the incentive to reduce membership. Increasing returns to labor can exist at low levels of labor input relative to land and capital. Under such circumstances, if the cooperative does not employ nonmembers, a point is eventually reached when any further decline in membership decreases X/L and thus lowers y.[12]

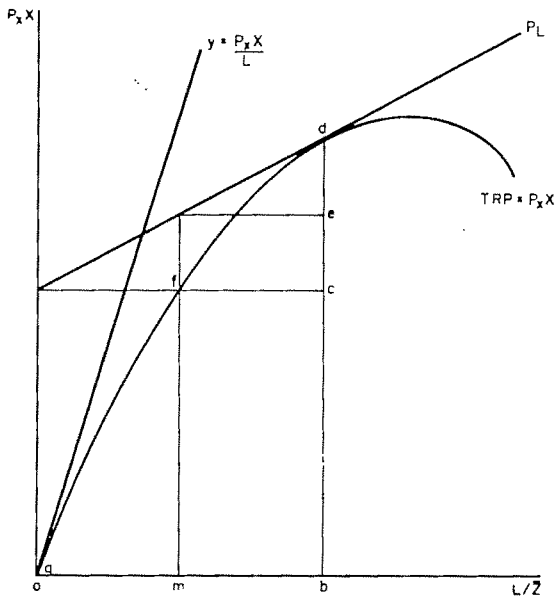


Figure 1. Short-run equilibrium of a cooperative

Recapitulating, the model hypothesizes a number of self-extinction forces that have worked aginst the long-run survival of production cooperatives. There is a desire to reduce

[11] Consider again a member two years before retirement. A particularly generous retirement scheme sets pensions in any year at 75% of y; the pension can be transferred to a surviving spouse. Assume the member expects himself or his spouse to live another twenty years after retirement. He would thus be willing to invest a dollar if

$$A\sum_{i=1}^{1}(1.06)^{-i} + 0.75\sum_{i=2}^{21}(1.06)^{-i} \geq 1;$$

i.e., $A \geq 10.5$. This represents an E factor of 4.5%.

[12] In a situation where a marketing or consumer cooperative failed to pay capital rents, members would receive this income as part of their patronage income. This would provide an incentive to reduce membership. However, unlike a production cooperative where labor input represents patronage, increasing returns are likely to exist over a considerable range of patronage (these increasing returns relate in particular to marketing economies and countervailing power). Such gains from increasing membership more than offset the loss associated with a decreased share of capital rents. As Youde and Helmberger point out, a marketing cooperative with considerable market power will eventually have an interest in restricting membership (an inverse relationship exists between patronage and product price).

membership, which in turn leads to an incentive to disinvest. The long-run financial viability of the firm is jeopardized by an increasing tendency to underinvest coupled with an increasing desire on the part of members to extract their equity. Finally, financial incentives exist for members to abandon cooperative ideals and hire wage-earning employees.

The Empirical Consistency of the Model: A Consideration of Some Case Studies

Two sets of case studies are examined in detail: a group of plywood cooperatives in the United States and two plantations in New Guinea.[13] An adequate time series of data are the main criteria for selecting the cases. Cases like the Israeli kibbutz are excluded on the grounds that noneconomic factors may obscure the hypothesized economic forces. As this model is concerned with the survival of financial successes, financial viability, at least initially, is a necessary requirement.

The U.S. Plywood Cooperatives

Data for these case studies were obtained from Bellas, Berman, and Worden.

Since 1921, there have been thirty-two plywood cooperatives in the Pacific Northwest region. They have constituted a significant but diminishing part of the industry. Despite a predominance of old, sometimes obsolete plants, the productivity of the cooperatives until the mid-1960s was significantly above the industry average.[14]

Membership of the cooperatives was obtained through share purchase. The number of shares sold was limited by the available jobs. Income was fixed to labor input. The benefits of being a shareholder accrued from working in the cooperative; rarely were dividends paid to shareholdings. Significantly, the majority of cooperatives reserved the right to purchase the shares of any member leaving the cooperative. Such purchases were at a price determined by the remaining members.

The cooperatives were predominantly self-financed, particularly those established before the Second World War. The Olympia Plywood Corporation, the largest of the cooperatives, was typical. After three years of operation, it had capital stock of $350,000 of which only $25,000 came from outside sources. Most of the cooperatives studied had bylaws in their constitution protecting the jobs of existing members. This supports the contention that any reduction in the working membership would be gradual.

Olympia clearly exhibited declining working membership. It was established in 1921 by 125 working members. In the subsequent successive years, the membership was 118, 108, 92, and 92. At the time of its sale in 1952, the number had dwindled to 45. During this period the firm expanded rapidly, so much so that it was purchased for stock valued at $15 million. During this period the cost of joining the cooperative continually increased.[15] Within very few years the price of the occasional Olympia share placed on the open market was prohibitive to younger and less well-off workers. Eventually, their price became prohibitive to all plywood workers.

The same sort of phenomenon was observed for the three other prewar cooperatives. For example, the Peninsula Plywood Company, established in 1941 by 280 worker shareholders, had only 240 working shareholders in 1958. During this period the value of the firm's capital assets had quadrupled.

In contrast, the cooperatives formed after the war experienced relatively little decline in working membership. This phenomenon is not contradictory to the explanation of the "paradox of success." These cooperatives were far less financially viable than their prewar counterparts. A depressed plywood market precluded the previous rapid rates of expansion. Hence, capital income accruing to members was far less, reducing the incentive to decrease working membership. In fact, some of these cooperatives were so chronically short of capital that they had to increase membership to raise sufficient capital for short-term survival. Further, a change in cooperative tax law in 1963 acted as an added disincentive to reduce membership. Following a court challenge, income distributed to cooperative members in accordance with

[13] I have examined in detail elsewhere a number of other case studies. These include the original Rochdale cotton mill, a nineteenth century British shoe cooperative, a twentieth century British chemical manufacturing cooperative, and the Yugoslav firm (McGregor 1974, pp. 27–30, 55–65, 86–99, 124–29). The findings were consistent with the cases presented here and thus for brevity have been excluded.

[14] A large number of cooperatives were established by employees of unprofitable conventional mills. They purchased mills that typically had run down and obsolete plant and equipment.

[15] Two years after Olympia was established, shares with a par value of $1,000 had a market value of $2,500. They eventually realized $120,000 when the cooperative was sold.

hours worked became tax deductible. For a firm to be classified as a cooperative for taxation purposes, it was necessary to maintain a high percentage of member workers.

Turning now to the employment of nonmember workers, the cooperatives established before the war displayed an increasing tendency to employ nonmembers. Olympia provides the most striking example. In 1922 out of a total work force of 218, 100 were not shareholders. By 1952 the firm had 45 working members and approximately 1,000 employees. Consistent with this model, the employees received considerably less remuneration than the members. (In 1922 employees received between $3.90 and $4.40 per day compared with $6.00 for members. By 1952 nonmembers received a daily wage of $15.60, approximately half the remuneration of members.) The postwar cooperatives also made increasing use of nonmembers. In 1956 six cooperatives employed only members, whereas by 1964 all cooperatives employed nonmembers. The replacement of member workers with nonmembers would render the hypothesized disinvestment force inoperative.

With regard to underinvestment, direct data are limited and difficult to evaluate. Nevertheless, some evidence of an increasing propensity to underinvest does exist. Over time there has been a steady decline in the productivity superiority of the cooperatives. (In the early 1950s, their productivity was, on the average, some 30% above that of conventional firms. By the late 1960s, the differential had all but disappeared.) Bellas attributes this to the much higher investment in new equipment by the conventional firms. Illustrative of this is that no cooperative has invested in a new plant since 1955. In contrast for the decade 1955–65, forty-one conventional firms invested in a new plant.

Evidence of an increasing desire on the part of members to extract their equity from successful cooperatives exists. Three financially successful cooperatives were sold within a working generation. Table 1 indicates the extent of the pecuniary benefits accruing to members from these sales.

Table 1. Financially Viable Plywood Cooperatives Sold

Cooperative Name	Year Formed	Year Sold	No. of Shareholders at Time of Sale	Sale Price ($1,000)
Olympia Plywood Corporation	1921	1954	65	15,000
Mutual Plywood Corporation	1950	1958	205	7,500
Anacortes Plywood Company	1930	1968	NA[a]	5,700

Note: To date four other cooperatives have been sold. These were financial failures that were sold very early in their life.
[a] The original working membership was 250.

The New Guinea Copra Plantations

Despite an expressed government policy to promote peasant proprietorship, a number of production cooperatives have evolved spontaneously. Eight of these cases have been documented since the war (Crocombe 1964, 1965, 1971; Crocombe and Hogbin; McGregor 1971). The author has first-hand knowledge of the two cases examined here.[16]

Both are located in the Manus region. One plantation, known as M'buke, comprises thirteen islands totaling 140 hectares. The other, known as Langandrowa, is on a single 104-hectare island.

The M'buke islands were planted by a German just prior to the First World War. The plantation was subsequently expropriated by the Australian Government in accordance with the Treaty of Versailles and sold to an Australian company. The M'buke people, the traditional claimants of the land, purchased the plantation in 1961. The M'bukes have operated the plantation as a cooperative, ignoring completely customary land rights.

The Langandrowa plantation was established at the turn of the century by a Japanese planter. It was expropriated as enemy property after the Second World War. The Mouk people, who now operate the plantation, obtained it as part of a government resettlement in 1965. Individuals were given leases to sixteen individual blocks. The government's intention was to have sixteen peasant holdings. This was not realized; forty-five Mouk families settled in a village and operated the plantation as one cooperative unit.

The M'buke plantation is owned and operated by a formal cooperative society (the

[16] The analysis is based on field work carried out during 1968–69. For a detailed analysis of the two plantations, see McGregor (1971, 1974). I also draw heavily on a previous study of the M'buke cooperative by Crocombe (1965).

M'buke Native Society Limited) and as such its activities are supervised by the Registrar of Cooperatives.[17] As a formal society, the M'buke cooperative was able to secure a $9,000 government loan to purchase the plantation. In contrast, Langandrowa is not a formal cooperative society.

In terms of productivity both cooperatives have performed particularly well. Despite the age of its trees, production per acre on Langandrowa has been some 30% above the national average for commercial plantations. Productivity increased ninefold under cooperative management. The productivity of the agronomically inferior M'buke plantation increased by 5% under cooperative management.

The M'buke cooperative initially paid substantial scarcity rents. By imposing a $28 per ton cess on sales, the government loan was repaid in three and a half years, a year and a half early. The cess was abandoned when the loan was finalized, and no further rents were extracted by the firm. (No rents were ever paid to the seven M'buke clans who contributed $4,000 to purchase the plantation.[18] Further, at the time of the field study no dividends had been paid to the shareholders.[19]) The Langandrowa cooperative has not extracted rents from the outset. The plantation was obtained for a nominal payment of $2 per annum for each of sixteen leases. Retained earnings has been the sole means of financing.

In October 1963, Crocombe reported the M'buke cooperative's working membership to be 107. By January 1969 it had declined to 91. During this period production was maintained and income per head had more than doubled. (It is significant that no villager under the age of twenty-five was a working member of the cooperative.) The M'buke case appears to be a particularly strong test of the declining working membership force. Here is a situation where cooperative members also belong to a cohesive village group with strong kinship ties. Yet, fellow villagers appear to have been denied working membership of the cooperative.

The Langandrowa cooperative had been in operation a relatively short period at the time of 1969 field work. Thus, any attrition in the existing membership could not be substantial. Nevertheless, a piece of evidence did exist that suggested that the force leading to declining working membership was becoming operative. In February 1969, a group of forty-six people from the previous Mouk village requested to join the cooperative. Despite the fact that these people had no arable land of their own, and their very strong kinship ties, the request was refused.

The employment of nonmembers on the irksome task of plantation clearing has been an increasing phenomenon on M'buke. In 1963 only 20% of clearing was done by nonmembers; by 1969 it had risen to 50%. As predicted, the remuneration of nonmembers was less than for members (64¢ per day compared with 88¢ per day for members.)

During 1968, 2% of Langandrowa's copra was gathered by outsiders. (Nonmembers received 1.6¢ per pound gathered, compared with 2.21¢ per pound for members.) Prior to this no outsiders were employed.

Some evidence of disinvestment was revealed on the M'buke plantation. M'buke's palms are old, yet no systematic replanting was observed. Even dead palms appeared not to be replaced. By 1969 copra driers, constructed by the cooperative in 1963, were in derelict condition.

Evidence of underinvestment on the M'buke plantation itself was not found in 1969. Investment opportunities were quite limited; the plantation was fully planted, and its physical nature precluded any mechanization. Nevertheless, strong *prima facie* evidence of the underinvestment force did exist. In 1968 the government offered the M'buke cooperative a ninety-nine-year lease on some nearby copra islands. For an initial investment of $700 and subsequent annual payments of $188, annual net revenue could have been increased by some $2,000 (assuming 1968 prices). The islands were not fully planted; thus, long-run revenue could have been increased by substantially more. The increased revenue could have been achieved without any apparent strain on labor resources. Yet, the cooperative members voted against foregoing current income to secure the islands.

[17] During the 1950s and 1960s the Australian administration vigorously promoted formal Rochdale marketing and consumer cooperatives at the village level. As a part of this program, the M'buke society was established in 1955 to market village copra and trochus shell and provide a retail store.

[18] The cooperative did not issue any shares for these collectively contributed funds. Thus, there was no potential for extracting rents through the payment of dividends.

[19] At the end of 1963 the cooperative's share capital was approximately $14,000 (share capital per member ranged from $10 to $165). The Registrar of Cooperatives vetoed the payment of any dividends for the first six years of operation on the grounds that the cooperative was severely undercapitalized.

There was no evidence of underinvestment for the newly formed Langandrowa cooperative. During its first few years of operation, substantial investments were made in transportation and processing facilities. The returns from these investments are likely to have been high due to the physical nature of the plantation.

Some Policies to Extract Scarcity Rents

Assume a cooperative obtained all its capital and land with funds secured from a perfectly competitive capital market. Under such circumstances, the firm's repayments reflect the scarcity value of these resources, and all the hypothesized self-extinction forces become inoperative. Let us briefly consider this proposition.

With all the cooperative's funds coming from a competitive capital market, the objective function becomes

$$(4) \qquad y = (P_x X - RZ - P_v V)/L,$$

where R is the competitive interest rate (i.e., society's rate of time preference).

The incentive to reduce membership is checked by the cooperative's debt obligation to the capital market. In figure 2, with $\bar{Z}$ capital and labor resources, y is maximized with

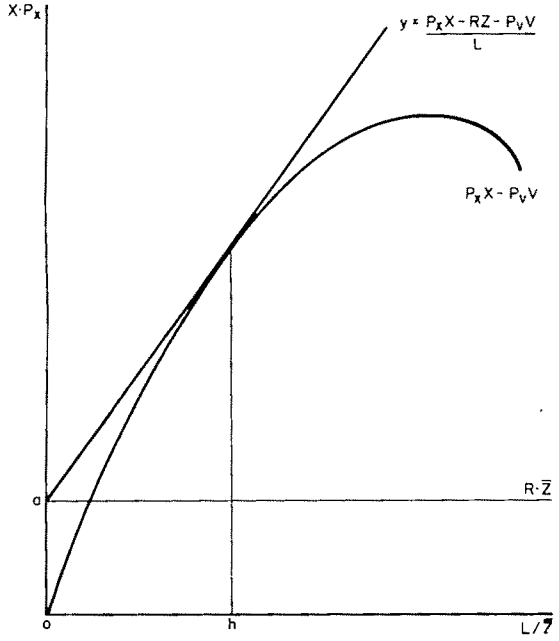


Figure 2. Short-run equilibrium of a cooperative (with scarcity rents)

oh members. (At equilibrium $MP_L = y$.) With all investment funds coming from the capital market and not from collective contributions, the underinvestment force is eliminated. The cooperative continues to borrow investment funds until their rate of return equals R. Furthermore, individual members do not continually build up equity in the cooperative; hence, the increasing desire to sell is removed. The financing of cooperatives through a perfectly competitive capital market reduces, and eventually eliminates, the incentive to employ nonmembers. The payment of a fixed debt obligation reduces y and thus the economic incentive to "exploit." Under perfectly competitive conditions, any remaining positive between y and P_L is eliminated by the establishment of new cooperatives.

A perfectly competitive capital market is of course an ideal that is unlikely to be approached in a realistic economy. For a low-income country, it would be unrealistic to assume the existence of a capital market that could facilitate anything near 100% external funding, particularly for an agricultural firm. Thus, the above discussion is only relevant in so much that it suggests a basic principle that must be adhered to in any policy proposal. This principle is that scarcity rents must be paid to nonlabor resources.

Rent Extraction by Government Legislation

This proposal draws heavily on Vanek, in cooperation with McGregor and Richards. It is worthy of note that elements of the Peruvian Social Property legislation incorporated some of the underlying principles discussed here (Davis, Gouverneur, Vanek 1973).

A government intent on establishing production cooperatives could extract scarcity rents by legislation. This could be achieved in the following manner. Land could be made available at a base scarcity rent. In addition to this base rent, the cooperative would be required to withdraw an amount equal to a fixed percentage of its capital stock annually, the rate reflecting capital's scarcity value.[20] Thus, if r^* reflects the combined scarcity of capital and land, and Z is the stock of capital and land, then r^*Z is withdrawn annually. Out of r^*Z the cooperative must meet any external debt obligation. The cooperative has three options for the remainder. It could reinvest in the

[20] An investment that improved the quality of land would be classified as an addition to capital stock.

cooperative. (It should be remembered that if θ_t was reinvested in the current year, the cooperative must extract $r^*(Z_t + \theta_t)$ the following year.) Alternatively, any part of the remainder could be used to establish new independent cooperatives or placed in a government fund. (The government fund would be used to provide land and finance for new cooperatives.) Any part of r^*Z not reinvested generates no further income to members nor do they have any further rent payment obligation for it. Under these circumstances, reinvestment in the cooperative would only be rational if the rate of return (A) exceeded r^*.

Such legislation produces the following objective function for cooperatives:

$$(5) \qquad y = (P_x X - r^*Z - P_v V)/L.$$

If $r^* \doteq R$, then substantially the same solution as results from a perfectly competitive market follows.

The fixed debt obligation for a given stock of capital and land checks the desire to decrease working membership.

For the amount r^*Z, members no longer have the choice between consumption and collective investment. It is either reinvested in the cooperative or foregone. It is irrational to underinvest, for it will always pay individuals to reinvest r^*Z so long as $A > r^*$. A further potential advantage of the proposal is that it may facilitate the movement of funds into more productive uses. (Any retained unproductive funds now incur a financial cost r^*Z.) For example, plantation agriculture, hitherto stagnating because of inadequate marketing facilities and land shortages, may have funds moving into the opening up of new land and establishing processing and transport facilities.

The extraction of r^*Z reduces any positive discrepancy between y and P_L and thus weakens the incentive to employ nonmembers. This follows not only from an increase in the fixed debt obligation of cooperatives but also from a possible fall in product price through increased industry output.

In a real world policy context the proposal may have considerable merit. The rate of r^* would be manipulated to achieve employment and output objectives. An upward adjustment in r^* could be used as a means of increasing productivity and employment. This can be seen in figure 3. (It should be noted that any reduction investment resulting from increasing r^* will modify this effect.)

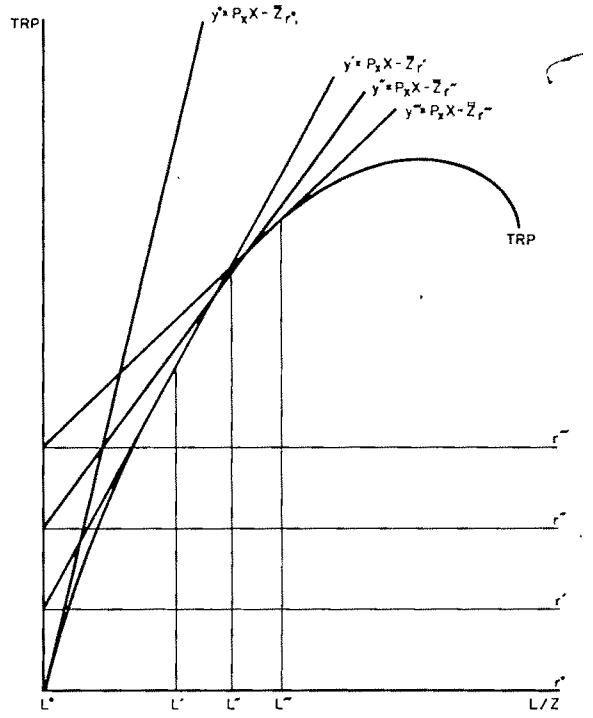


Figure 3. The effect of changes of rents on employment and income

Intrafirm Rent Extraction: Rochdale Cooperatives and Lessons from the Pioneers

Since the Second World War a number of governments have promoted formal Rochdale cooperatives as part of their rural development program. In keeping with the traditions of the Rochdale movement, this has invariably meant the promotion of marketing and consumer societies. Nevertheless, while production cooperatives were not seen as the goal, they have resulted in a number of instances (Crocombe 1971, p. 171). Usually, as with our M'buke case, these "Rochdalean" production cooperatives evolved from previously established marketing or consumer societies.

The system of financing that these "Rochdalean" production cooperatives have inherited potentially provides an intrafirm means of overcoming the hypothesized self-extinction forces. Like most marketing and consumer societies, they issue shares to individual members in accordance with their capital contributions, with bonus shares often being issued when any surplus is retained (all members having equal voting rights regardless of their shareholding). If dividends are paid that

approximately reflect capital's scarcity value, the incentive to continually reduce working membership is eliminated (assuming land has not been provided as a government grant and bonus shares are always issued when earnings are retained).[21] This follows because the residual income accruing to the members would represent the contribution of their labor alone. (The incentive to disinvest would be eliminated *pari passu*.) The underinvestment force would also be eliminated if individual members can redeem their shares on retirement. (With bonus shares being issued when earnings are retained, an individual's shareholding would reflect his contribution to the cooperative's capital stock.)

Notwithstanding the potential for intrafirm rent extraction, insufficient internal funds may be available to establish a viable enterprise. The purchase of land alone may be beyond the collective means of a group of rural workers or peasants. (The New Guinea case studies are examples of this.) With the relative fixity of land necessarily limiting the working membership, a temptation may exist to attract nonworking members as a means of raising capital. Such an action could prove disastrous for the cooperative. A valuable lesson in this respect can be learned from a brief examination of the important historical case of the Rochdale Pioneers.[22]

Initially, the Pioneers saw in production cooperatives a means of improving the lot of workers. To this end they established in 1854 a cooperative cotton mill. To begin with, most of the hundred or so shareholders worked in the mill. The few nonworking members were altruistic Pioneers; their capital was required to lease a room from an established mill. As shareholders the nonworkers were given full and equal voting rights. Despite an acute capital shortage, the cooperative fared better than most mills during the severe 1857–58 market slump. To quote the "Rochdale Observer":

> The disastrous years of 1857 and 1859 sorely tried this infant establishment; and, although during a period of fifteen weeks no sales were effected, or sales only to a trifling amount, yet the hands were never put on short hours, although other mills in town yielded in this respect to the pressure of the times (Jones, p. 260).

The subsequent 1859 price boom left the cooperative in a very favorable economic position. It began to attract members who had little or no involvement with the cooperative movement. These new members were not required to work in the mill, and few did. The cooperative actively encouraged nonworking members to finance a £34,000 mill. By the end of 1860, the "cooperative" had 1,400 shareholders of whom only 200 worked in the mill. All the management committees were made up exclusively of nonworkers. The previous policy of distributing the trading surplus among the working members was abolished. Instead, workers were now paid a fixed wage that was little above the going rate for the industry. A dejected Pioneer, Abraham Greenwood, described what had occurred:

> It was the success of the society that attracted to it persons who only cared for the eternal "divi." These people brought into the society their money very rapidly for shares, thus raising the number of shareholders from 200 or 300 to 1,400. It was the new shareholding element that swamped the original promoters of what was then called "Bounty to Labour" (Jones, p. 262).

While a production cooperative should never admit nonworker members, outside investors should not be discouraged. It could sell, the capital market permitting, bonds and debentures to outsiders. This stock would exercise no control but would facilitate rent extraction at the market rate of interest. (Payments to bond and debenture holders are made before any surplus is distributed among the members.)

Summary and Conclusions

Since the Second World War there has been a revival of interest in production cooperatives, particularly in the agricultural sectors of low-income countries. For an increasing number of third world policy makers, the production cooperative appears to offer a superior alternative to both the private and state corporations.

[21] In practice many Rochdale societies pay dividends well below the market rate of interest. The M'buke cooperative provides an extreme example. In the first six years it operated the plantation, no dividends were paid.

[22] Data for the following brief discussion are derived from Bonner, Jones, and Potter. This case represents an historic turning in the Rochdale movement. It led to the disillusionment of the Pioneers with production cooperatives, and they turned their energy entirely to consumer societies. The case so influenced the Fabian socialists that they actively campaigned against production cooperatives. (The Fabian socialists in Britain played a vital role in consolidating consumer cooperatives in the latter half of the nineteenth century.)

If history can be our only guide, we can only be pessimistic regarding the survival prospects for these firms. An historical review revealed that nineteenth century cooperatives seldom lasted more than a decade—paradoxically, the survival rate being no better for financial successes. It was shown that, if scarcity rents are not extracted from land and capital, a New Guinean cooperative copra plantation will meet the same fate as the Wolverhampton locksmith societies a century ago. In fact, the demise of the New Guineans may be faster due to the production relationships of plantation agriculture.

Yet, this paper should provide grounds for optimism, not gloom, for present-day cooperators. Policies can be readily devised to facilitate rent extraction. The principle of rent extraction seems equally amenable to government legislation as it is to intrafirm policy.

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Inflation-Indexed Price Supports and Land Values

Duane G. Harris

A theoretical model is developed to examine and illustrate some relationships between cost-indexed support prices and land values. The model is developed in the context of a single-commodity, price-uncertain world in which policy makers are allowed to control the percentage of nonland operating costs and the percentage of land costs covered by the support price. The model demonstrates that the time path of land values can be quite sensitive to policy parameters. Attempts by policy makers to guarantee a "fair" rate of return on land may have substantial impact on future land values.

Key words: farm policy, land value, support price, target price.

Land prices have an impact on a wide range of participants in an economy. They have a direct impact on farmers' abilities to begin, operate, and expand their enterprises. Consumers worldwide are affected indirectly by land values because the cost of land services partly determines the supply of farm commodities. Taxing authorities are directly affected by land value changes because property values are used as the basis for property tax assessment.

In addition to such factors as farm income, farm enlargement, and expected capital gains, many studies have documented the influence of government farm programs on land values. For example, Reynolds and Timmons find, by using 1933–65 aggregate U.S. data, that payments made through government farm programs are indeed capitalized into farmland value. Boxley and Anderson summarize various studies that show positive values for tobacco allotments. Hedrick documents that benefits of the peanut program are capitalized into land values in North Carolina.

With the adoption of the Agriculture and Consumer Protection Act of 1973, however, the thrust of farm programs in the United States was changed. Programs to restrict supply were replaced with ones to promote production. Policies to stabilize commodity prices were replaced by a new policy of target prices. Although it is not clear that future farm programs will take the form of the 1973 Act, general interest in the inflation indexing of economic variables likely will cause some form of cost-indexed price supports to be considered seriously in the future.[1]

Unfortunately, because of limited experience with inflation indexing, it is not possible to empirically document or project the impact of cost-indexed support prices on land values. It is possible, however, to develop and illustrate some of the potential important relationships between support-price policies and land values. The purpose of this article is to present such conceptual relationships.[2]

In the next section, a theoretical model of land value determination is developed to incorporate support prices. Then, the model is illustrated for different assumptions about the implementation of support-price policy. Finally, a summary and some conclusions of the study are presented.

Duane G. Harris is an associate professor in the Department of Economics, Iowa State University.

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[1] For example, escalator clauses in labor contracts, automatic inflation adjustments in retirement and pension plans, and inflation-indexed bonds all represent inflation-indexing mechanisms.

[2] The analysis is confined to an examination of the impact of cost-indexed support prices on land values. No evaluation is made of the impact of support-price policy on stability of commodity prices or on income support in the farm sector.

A Model of Support Prices and Land Values

General Framework

Assume a simplified world in which one commodity is produced from land in time period t. Also assume that the future level of per acre production Q_t is certain and constant. If the farmer sells the commodity at random unit price P_t and incurs the certain per acre cost of production (exclusive of land cost) C_t, then the farmer's per acre net return to land can be written as

$$R_t = P_t Q_t - C_t, \tag{1}$$

where price uncertainty constitutes the only source of risk and causes net return to be a random variable. The expected level of net return per acre is thus given by

$$E(R_t) = E(P_t)Q_t - C_t, \tag{2}$$

and the variability of return is given by

$$\sigma_{R_t}^2 = Q_t^2 \sigma_{P_t}^2. \tag{3}$$

Furthermore, by assuming that the expected probability distribution for future prices is constant so that the expected value and variability will be the same in all future time periods, the value of farmland V_t is given by the standard valuation formula

$$V_t = \frac{E(R_t)}{k}, \tag{4}$$

where k is the capitalization rate given by

$$k = a + b\sigma_{R_t}^2. \tag{5}$$

In equation (5), the coefficient a represents the risk free rate and b is the unit increase in k brought about by a change in risk as measured by $\sigma_{R_t}^2$. Any factor that causes expected return to increase increases land value. For a risk averter, any factor that causes variability (risk) to increase increases the capitalization rate and thus decreases land value.[3]

Support-Price Mechanism

Suppose that, as a matter of policy, a support price X_t is automatically implemented as a function of the per unit cost of production of the commodity. Specifically, let

$$X_t = \frac{\gamma_C C_t + \gamma_L L_t}{Q_t}, \tag{6}$$

where C_t/Q_t represents the operating cost, L_t/Q_t represents the land cost per unit of production, and γ_C and γ_L are policy decision parameters used to establish the proportion of operating and land charges that will be recaptured via the support price per unit of the commodity.

By assuming

$$C_t = \delta C_{t-1} \tag{7}$$

and

$$L_t = \lambda V_{t-1}, \tag{8}$$

equation (6) can be rewritten as

$$X_t = \frac{\gamma_C \delta C_{t-1} + \gamma_L \lambda V_{t-1}}{Q_t}. \tag{9}$$

Equation (7) defines current operating costs as proportional to last period operating costs, where δ represents the value $(1 + c)$ and c is the rate of growth (decline) in operating costs. Equation (8) establishes total land charges as a return on last period land value, where λ is the rate of return and is a policy decision parameter that is established as the allowable rate of return on farmland that can be considered as a land charge for support-price purposes.

Price Expectations and Land Values

To identify the expected returns and capitalization rate necessary for the determination of land value, it is necessary to postulate a farmers' subjective probability distribution for commodity prices. To keep the analysis simple, the distribution is assumed uniform, ranging from the support price X_t as the lower bound to U_t as the upper bound.

It is assumed that the support-price mechanism changes the subjective probability distribution. For example, a loan rate mechanism establishes a floor on the distribution of market prices and thus bounds the farmers' distribution of expected prices from below. A target price formula, although it does not alter the distribution of market prices, changes the farmers' distribution of expected prices because the formula provides for a transfer of income to make up any deficiency between market price and the target price. As used in

[3] Valuation formula (4) could be modified to accommodate net returns that grow at a constant rate g over time. In that case, $V_t = E(R_t)/r$, where $r = (k - g)$. In such a model, expected returns would grow over time, but the variability of returns would remain constant such that the capitalization rate would be constant over time.

this paper, the support-price mechanism is generalized to accommodate either a target price or loan rate program. (For a discussion of current loan rate and target price formulas, see Penn and Brown.)

Furthermore, once the support price is established by the policy authority, assume farmers expect that policy to prevail forever. If the policy authority changes the support price, farmers revise their expectations but again believe that the new support price will prevail forever. Thus, at any given time, farmers are basing the valuation of land on an expected distribution of returns that is constant over all future years.[4]

Also, if the support price is changed, the mean of the distribution is assumed to shift, but the variance remains unchanged. For example, if the support price is increased by x units, the upper bound of the distribution also increases by x units.[5]

The upper bound of the distribution U_t can be defined as the sum of the lower bound X_t and the range RG_t. From equation (9),

$$(10)\quad U_t = \frac{\gamma_C \delta C_{t-1} + \gamma_L \lambda V_{t-1}}{Q_t} + RG_t.$$

The first two moments of the uniform distribution give expected price and variance of price as

$$(11)\quad E(P_t) = (U_t + X_t)/2 = \tfrac{1}{2}\,[RG_t + [2(\gamma_C \delta C_{t-1} + \gamma_L \lambda V_{t-1})]/Q_t]$$

and

$$(12)\quad \sigma_{P_t}^2 = (U_t - X_t)^2/12 = RG_t^2/12.$$

Substituting equations (11) and (12) into equations (2) and (3) gives expected return and risk as

$$(13)\quad E(R_t) = \tfrac{1}{2}\,[RG_t + [2(\gamma_C \delta C_{t-1} + \gamma_L \lambda V_{t-1})]/Q_t]\, Q_t - C_t$$

and

$$(14)\quad \sigma_{R_t}^2 = Q_t^2 RG_t^2/12.$$

Finally, substituting equation (14) into equation (5) and then equations (13) and (5) into equation (4) gives land value as

$$(15)\quad V_t = \{\tfrac{1}{2}[RG_tQ_t + 2(\gamma_C \delta C_{t-1} + \gamma_L \lambda V_{t-1})] - \delta C_{t-1}\}/[a + b(Q_t^2 RG_t^2)/12].$$

By rearranging equation (15), the valuation formulation is given as a linear first-order difference equation

$$(16)\quad V_t - \frac{12\gamma_L \lambda}{12a + bQ_t^2 RG_t^2} V_{t-1} = \frac{6RG_tQ_t + 12\delta C_{t-1}(\gamma_C - 1)}{12a + bQ_t^2 RG_t^2}$$

or

$$(17)\quad V_t - \left(\frac{\gamma_L \lambda}{k}\right) V_{t-1} = [\tfrac{1}{2}RG_tQ_t + \delta C_{t-1}(\gamma_C - 1)]/k.$$

The solution value for equation (17) is given by

$$(18)\quad V_t = (V_0 - \varphi)(\phi)^t + \varphi,$$

where

$$(19)\quad \varphi = \frac{\tfrac{1}{2}RG_tQ_t + \delta C_{t-1}(\gamma_C - 1)}{k - \gamma_L \lambda},$$

$$(20)\quad \phi = \gamma_L \lambda / k,$$

and V_0 is some initial land value.

Policy Prescriptions and Land Values

The time path of land values is crucially related to the sizes of the policy parameters in the model. The general form of the time path is dependent on the size of ϕ in equation (18). Because $\phi = \gamma_L \lambda / k$, the path is determined by the relationship between the effective return on land allowed by policy ($\gamma_L \lambda$) and the market capitalization rate on land (k). If policy makers guarantee nothing above operating costs ($\gamma_L \lambda = 0$), the time path of land values is constant. If policy makers allow an effective rate of return less than the market rate ($0 < \gamma_L \lambda < k$), the time path is nonoscillatory and damped. If policy makers build in an effective rate of return equal to the market capitalization rate ($\gamma_L \lambda = k$), the time path is linear with positive slope. Finally, if policy makers set policy parameters such that the effective rate of return on land is greater than the market capitalization rate ($\gamma_L \lambda > k$), then the time path is nonoscillatory and explosive (figure 1).

Both the value maximum and the rate at which land values approach that maximum are influenced by support-price policy decisions. Although φ is a function of both γ_C and γ_L, ϕ is

[4] The expected distribution of returns with support prices remains unchanged even in times of increased supply and depressed market prices. Thus, even though the supply of land services may not be perfectly inelastic, the support price guarantees that expectations do not change concerning the annual net return of farmland.

[5] This assumption is necessary to conform to the assumption that the capitalization rate is constant over all time periods.

a function only of γ_L. So, changes in the proportion of operating costs covered by the support price affect the maximum that land values achieve over time. Changes in the proportion of land charges that are covered by the support price affect the land value maximum and the rate at which land values approach that maximum.

More specifically, the impact of changes in policy parameters on the time path of land values can be evaluated using comparative dynamics (Gandolfo, pp. 359–60). By differentiating totally the solution function (equation (18)) with respect to γ_C, γ_L, λ, and δ, the influence of policy parameters and exogenous factors can be discerned:

$$(21)\quad \frac{dV_t}{d\gamma_C} = \frac{\delta C_{t-1}}{k - \gamma_L\lambda}\left[1 - \left(\frac{\gamma_L\lambda}{k}\right)^t\right] > 0,$$

$$(22)\quad \frac{dV_t}{d\gamma_L} = t\left(\frac{\lambda}{k}\right)^t\left\{V_0 - \frac{[\frac{1}{2}RG_tQ_t + \delta C_{t-1}(\gamma_C - 1)]\gamma_L^{t-1}}{k - \gamma_L\lambda}\right\} + \frac{[\frac{1}{2}RG_tQ_t + \delta C_{t-1}(\gamma_C - 1)]\lambda}{(k - \gamma_L\lambda)^2}\left[1 - \left(\frac{\gamma_L\lambda}{k}\right)^t\right] > 0,$$

$$(23)\quad \frac{dV_t}{d\lambda} = t\left(\frac{\gamma_L}{k}\right)^t\left\{V_0 - \frac{[\frac{1}{2}RG_tQ_t + \delta C_{t-1}(\gamma_C - 1)]\lambda^{t-1}}{k - \gamma_L\lambda}\right\} + \frac{[\frac{1}{2}RG_tQ_t + \delta C_{t-1}(\gamma_C - 1)]\gamma_L}{(k - \gamma_L\lambda)^2}\left[1 - \left(\frac{\gamma_L\lambda}{k}\right)^t\right] > 0,$$

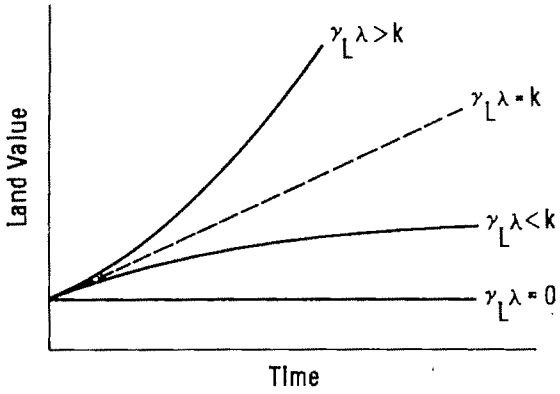


Figure 1. Time path of land values

and

$$(24)\quad \frac{dV_t}{d\delta} = \frac{C_{t-1}(\gamma_C - 1)}{k - \gamma_L\lambda}\left[1 - \left(\frac{\gamma_L\lambda}{k}\right)^t\right] \gtreqless 0 \text{ as } \gamma_C \gtreqless 1.$$

An increase in the proportion of operating costs covered by the target price (γ_C) *ceteris paribus* results in higher land values at every point in time. Increases in either the allowed rate of return on land (λ) or the proportion of land charges covered by the support price (γ_L) *ceteris paribus* also lead to higher land values at every point in time. An increase in the rate of inflation of operating costs (δ) *ceteris paribus* everywhere increases land values if more than 100% of operating costs are covered by the target price ($\gamma_C > 1$). If exactly 100% of operating costs are covered ($\gamma_C = 1$), an increase in δ *ceteris paribus* results in no change in land values. If operating costs are not fully covered ($\gamma_C < 1$), an increase in δ *ceteris paribus* leads to lower land values at every point along the time path.

Numerical Example

Although an examination of equation (18) provides qualitative information about the time path of land values in a support-price world, explicit specification of the parameters and variables in the model is necessary to assess the quantitative impact of farm-policy changes. Suppose the model is evaluated for a cash-grain situation in which corn is the single commodity produced and where the following parameter and variable values are reasonable for the cash-grain example: $Q_t = 100$ bushels per acre, $C_{t-1} = \$150$ per acre, $\delta = 1.00$, $V_0 = \$1{,}667$ per acre, $RG_t = \$2.00$ per bushel, $a = 0.02667$, and $b = 0.00001$. Also, assume that the policy parameters initially are set as follows: $\lambda = 0.09$, $\gamma_C = 1.00$, and $\gamma_L = 0$.

In this setting, the initial support price X_0 is \$1.50 per bushel, so the farmers' subjective probability distribution for corn prices ranges from \$1.50 per bushel to \$3.50 per bushel, with an expected value of \$2.50 per bushel. The capitalization rate k is 0.06.[6] Policy makers are

[6] It is more nearly correct to assume that the capitalization rate for farmland is given by equation (4) as modified in footnote 3. Thus, the income capitalization rate is given by the difference between the owners' required rate of return and the expected growth rate ($k - g$). For example, in terms of the parameters in the numerical example, a 6% capitalization rate (r) is consistent with a required rate (k) of 12%, a risk-free rate (a) of 2.667%, a risk premium ($b\sigma_{R_t}^2$) of 9.333%, and a growth rate (g) of 6%.

assumed to allow a return on land λ equal to 0.09, a long-term average of mortgage rates on farm real estate loans. Furthermore, the support-price policy is established by covering 100% ($\gamma_C = 1.00$) of operating costs and 0% ($\gamma_L = 0$) of land charges. Operating costs are assumed constant over all future periods. The time path of land values for this scenario is shown in column 2 of table 1. Land values remain constant at $1,667 per acre, and the support price is constant at $1.50 per bushel.

If policy makers decide to set the support price formula to recapture a portion of land costs ($\gamma_L > 0$), however, the path of land values increases over time. Solution values for the model for selected values of γ_L greater than zero are shown in columns 3 through 8 of table 1. The equilibrium value for land increases from $1,667 per acre to $6,665 per acre as γ_L is changed from 0 to 0.50. Thus, the greater the proportion of land charges that policy makers allow to be recaptured through the support price, the larger is the long-run equilibrium price of land. In other words, any guaranteed return to land—above and beyond operating costs—is capitalized into the price of land. An increase in the value of land necessitates an increase in the support price, which increases the expected returns to land, which increases land value, which requires a further increase in the support price, and so on.

In this numerical example, as long as $\gamma_L\lambda < 0.06$, land values increase at a decreasing rate over time. With $\lambda = 0.09$, however, if $\gamma_L > 0.667$, land values explode—values increase at an increasing rate. An illustration of exploding land value is given in column 10 of table 1. In that instance, $\gamma_L = 0.70$; thus, $\gamma_L\lambda = 0.063$, which is greater than the market capitalization rate of 0.06.

Table 2 presents the dollar and percentage changes in land values over time for each of the policy schemes. For example, row 5 shows that after five years land values have increased $294 per acre or 18% for $\gamma_L = 0.10$. Over that same time interval, land values have increased $3,812 per acre or 229% if γ_L is set at 0.50. Thus, the particular scheme used to implement a support-price policy could have substantial impact on the future path of land values.

Also, the potential social cost of the different schemes could differ substantially. For the first year of policy implementation, the difference between the required support prices for the $\gamma_L = 0$ case and the $\gamma_L = 0.50$ case is $0.75 per bushel (table 1). By year five, that support-price differential increases to $2.29 per bushel. At their equilibrium levels, the difference in support prices is $3.00 per bushel.

Summary and Conclusions

In this paper, policy makers are allowed to control the percentage of nonland operating costs and the percentage of land costs covered by commodity support prices. If policy authorities establish a support-price formula that recaptures all nonland operating costs but no return on land, the time path of land values is level or constant. Thus, implementation of that type of policy has a once-and-for-all impact on land values, raising them to a new equilibrium level.

Table 1. Support Prices and Land Values for Selected Policy Schemes

	$\gamma_L = 0$		$\gamma_L = 0.10$		$\gamma_L = 0.30$		$\gamma_L = 0.50$		$\gamma_L = 0.70$	
t	X_t	V_t	X_t	V_t	X_t	V_t	X_t	V_t	X_t	V_t
0	$1.50	$1,667	$1.50	$1,667	$1.50	$1,667	$1.50	$1,667	$1.50	$1,667
1	·	·	1.65	1,917	1.95	2,417	2.25	2,917	2.55	3,417
2	·	·	1.67	1,954	2.15	2,754	2.81	3,854	3.65	5,254
3	·	·	1.68	1,960	2.24	2,906	3.23	4,557	4.81	7,183
4	·	·	·	1,961	2.28	2,974	3.55	5,084	6.03	9,208
5	·	·	·	·	2.30	3,005	3.79	5,479	7.30	11,335
6	·	·	·	·	2.31	3,019	3.97	5,776	8.64	13,567
7	·	·	·	·	2.32	3,025	4.10	5,998	10.05	15,512
8	·	·	·	·	·	3,028	4.20	6,165	11.52	18,373
9	·	·	·	·	·	3,029	4.27	6,290	13.07	20,957
10	·	·	·	·	·	3,030	4.33	6,384	14.70	23,670
15	·	·	·	·	·	·	4.46	6,598	24.15	39,409
30	1.50	1,667	1.68	1,961	2.32	3,030	4.50	6,665	71.19	117,807

Note: t = time period; γ_C = proportion of nonland costs covered by support price = 1; γ_L = proportion of land costs covered by support price; X_t = support price per bushel; and V_t = land value per acre.

Table 2. Cumulative Land Value Changes for Selected Policy Schemes

t	$\gamma_L = 0.10$		$\gamma_L = 0.30$		$\gamma_L = 0.50$		$\gamma_L = 0.70$	
1	$250	15%	$750	45%	$1,250	75%	$1,750	105%
2	287	17	1,087	65	2,187	131	3,587	215
3	293	18	1,239	74	2,890	173	5,516	331
4	294	·	1,307	78	3,417	205	7,541	452
5	·	·	1,338	80	3,812	229	9,668	580
10	·	·	1,363	82	4,717	283	22,003	1,320
15	·	·	·	·	4,931	296	37,742	2,264
30	294	18	1,363	82	4,998	300	116,140	6,967

Note: t = time period; γ_C = proportion of nonland costs covered by support price = 1; γ_L = proportion of land costs covered by support price; $ = dollar change in land value per acre over t time periods; and % = percentage change in land value per acre over t time periods. For $\gamma_L = 0$, $ = % = 0.

If, however, policy makers allow a portion of the rate of return on land to be included in the support-price formula, land values increase over time and approach an equilibrium value greater than for the situation in which no land costs are included in the support price. Both the level of the new equilibrium and the rate at which land values approach that equilibrium are affected by the proportion of land charges included in the support-price formula. In the extreme case, if policy makers inadvertently allow an effective return on land greater than the market capitalization rate, land values explode.

Thus, the particular scheme used to implement a general cost-indexed support-price policy is likely to be crucial to the resulting impact on future land values and also to the possible social cost of the farm program for years in which actual commodity price falls below the support price. It is unreasonable to expect that policy makers would allow an explosive mechanism to track very far into the future. Implementation of a policy that guaranteed a rate of return on land greater than the market capitalization rate, however, could have substantial impact on land values before the policy parameters could be adjusted.

The model could be used to consider a wide range of schemes, other than those considered above, to implement inflation-indexed support-price programs. For example, one suggested support-price formula would have the support price include a fixed dollar return to land (Sharples and Krenz). The model suggests that such a policy would result in a constant land value over time as long as operating costs were constant ($\delta = 1$). Or, the model could be used to evaluate the consequences of inaccurate measurement of nonland operating costs. Preliminary analysis suggests that, for example, an overestimate of nonland operating costs in a support-price formula generates the same time path of land values as the model results obtained with $\delta = 1$, $\gamma_L = 0$, and $\gamma_C > 1$.

The model was developed using simplifying assumptions that, when relaxed, might alter the conclusions of the analysis. Without doubt, quantitative results would be changed, although the qualitative implications of the model likely would remain intact. For example, the variance of the expected price distribution was assumed to remain constant as the support price increased. It is possible that as the support price increased the variance of the distribution would decline. In such a case, for the uniform distribution, the expected value would increase less, and thus, *ceteris paribus*, land values would not increase as much as for the constant variance case. As the variance narrowed, risk would decline, the capitalization rate would fall and cause a *ceteris paribus* increase in land values. The net effect of a constant variance assumption would depend on the relative sensitivity of land values to changes in expected returns and risk.[7]

Also, it was assumed that farmers naively expect new support prices to hold forever. In reality, farmers likely would anticipate the future movement of the support price and build that anticipated movement into their expected return from land. Land values in such an anticipatory model would increase at a faster rate than those in the naive model.

In addition, the farmers' distribution of expected prices was assumed uniform to make the mathematical model tractable. The use of

[7] For purposes of numerical analysis, the model was modified by assuming that the upper limit on the probability distribution of prices U_t was constant. In that situation, as the support price X_t increased, the expected value of the distribution increased and the variance decreased as the range narrowed. Consequently, the capitalization rate declined each time the support price increased. The quantitative results of the model were more extreme because the capitalization rate was quite sensitive to changes in the variance.

some other distributional form likely would not significantly change the results of the model if the distribution was symmetrical and variance was assumed constant. With variance constant, a shift in any symmetrical distribution brought about by a change of x units in the support price would produce a shift in the expected value of the distribution by that same x units. If, however, the variance of the distribution changed as the support price changed, the form of the distribution could have an effect on the quantitative results of the model.

Finally, the time paths of land values were developed in a *ceteris paribus* context, where only policy variables were allowed to change. In the real world, many other factors besides farm policy affect land values, so the time path of land values will not follow the track of those generated by the model. But, if nothing else, this analysis demonstrates the potential importance of the selection of an appropriate scheme for the implementation of well-intentioned social and policy goals.

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Analysis of the Impact of Alternative U.S. Dairy Import Policies

Larry Salathe, William D. Dobson, and Gustof A. Peterson

A simulation model is used to measure the impact of four U.S. dairy import plans on Wisconsin farm milk prices and other variables. Estimates for different plans show that each additional billion pounds of milk equivalent in dairy imports would depress Wisconsin farm prices initially by $0.14 to $0.21 per hundredweight. Wisconsin farm milk prices initially would fall by 18% if the milk equivalent of butter and cheese imports rose to 12 billion pounds. Within three years, milk prices would recover. But this recovery would occur only after about 13% of Wisconsin's milk producers had exited from dairying.

Key words: dairy imports, farm numbers, international trade, milk prices, simulation model.

U.S. trade officials in recent years have striven to reduce barriers—particularly those in the European Economic Community (EEC) countries—to exports of U.S. agricultural products. The results achieved by U.S. negotiators have been meager. Agricultural trade negotiations during the Kennedy round, which began in 1967, did little to reduce barriers to expanded exports of U.S. farm products. Moreover, bilateral negotiations by U.S. officials with other countries since the Kennedy round and recent negotiations in multinational forums (e.g., those authorized by the Trade Act of 1974) have achieved no agricultural trade expansion breakthroughs as of early 1977.

These failures have spawned proposals for different negotiating strategies, including the "selective goal" strategy of the Flanigan International Trade Report (Council on International Economic Policy). This strategy would have the U.S. seek freer trade in a few agricultural products rather than across-the-board agricultural trade liberalization. Authors of the Flanigan report said that the U.S. should, if necessary, give up its dairy import quotas to gain freer access to foreign markets for feed grains and soybeans. Under a full-market orientation option examined in this report, the U.S. would substantially expand feed grain and soybean exports while importing manufactured milk products containing 12 billion pounds of milk equivalent by 1980. The 12 billion pounds of milk equivalent represent about 10% of total U.S. milk consumption and the equivalent of 25% of U.S. manufactured milk product consumption. The Atlantic Council argued that it would be reasonable for the U.S. to permit imports of dairy products to increase from the present 1.5% of domestic consumption to 10% of domestic consumption by 1980. Authors of the Flanigan and Atlantic Council reports contend that economic adjustments that would be required of the U.S. dairy industry to accommodate dairy product imports equal to 10% of U.S. consumption would be small—almost imperceptible over a ten-year period according to the Atlantic Council report (p. 247).

The Flanigan and Atlantic Council reports aroused concern in the U.S. dairy industry for several reasons. First, dairy import quotas were thought to be the only major agricultural concession that the U.S. had to offer in trade negotiations. Accordingly, it was feared that U.S. trade negotiators might seek permission to put the quotas "on the table" to be exchanged for trade concessions from other nations. Second, the administration temporarily lifted import quotas on some manufactured milk products during 1973 and 1974, contributing to a 20% decline in U.S. average manufac-

Larry Salathe is a research associate, William D. Dobson is the chairman, and Gustof A. Peterson is a professor in the Department of Agricultural Economics, University of Wisconsin, Madison.

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tured milk prices in 1974. The lifting of quotas was interpreted by some in the dairy industry as evidence that the U.S. government was implementing the recommendations of these reports. Third, many thought that the U.S. dairy industry would need to make major, painful economic adjustments if larger manufactured milk product imports were permitted. Fourth, there was concern that, if larger dairy imports were permitted, then the U.S. dairy price support program would be eliminated or modified.[1]

Partly in response to these concerns, the U.S. Congress directed the U.S. Department of Agriculture to study the effects of expanding dairy imports in 1973. Among other things, this study, which was forwarded to Congress in 1975, examined effects of an open U.S. market policy that assumed no U.S. dairy import quotas or price-support program. Under this policy, the U.S. would have imported the milk equivalent of 12.2 and 13.4 billion pounds of manufactured dairy products in 1975 and 1976, respectively, and smaller quantities in subsequent years. The USDA estimated that every billion pounds of milk equivalent imported would reduce U.S. farm milk prices by about $0.18 per hundredweight. Consequently, the assumed 1975 dairy product imports would have caused 1975 U.S. average farm milk prices to fall to a level about $2 (22%) below the $8.90 price that would prevail under present dairy import laws. The USDA concluded that U.S. dairy farmers initially would experience harsh economic conditions but that those who survived the depressed prices of the open U.S. market policy for two or three years would see their returns rise to levels about equal to those that would prevail under present dairy programs.

The Comptroller General's 1976 report to the U.S. Congress on import restrictions also suggested that the U.S. should reduce barriers to dairy imports. However, this report concluded that complete and sudden elimination of all barriers to dairy imports would be disruptive and could result in unreasonably adverse impacts on domestic milk producers. The report called for studies of the impact of policies that permit moderate increases in dairy imports in order to identify viable alternatives to present U.S. dairy programs.

The previous reports yield insights about the effects of larger dairy product imports. However, the earlier studies, especially the Flanigan and Atlantic Council reports, give little detailed information about the nature of the adjustments the domestic dairy industry would need to make if U.S. dairy imports were increased substantially. The estimates of the Flanigan, Atlantic Council, and the USDA reports apparently conflict with respect to the amount of damage the domestic dairy industry would sustain if dairy imports were increased sharply. The USDA seems to conclude that the damage would be substantially greater than suggested in the Flanigan and Atlantic Council reports. Moreover, the earlier studies deal primarily with the entire U.S. dairy industry or larger economic aggregates. Therefore, they show little about how larger manufactured milk imports would affect the dairy industry of major milk-producing states such as Wisconsin, where economic damage from dairy imports could be most severe.

This study evaluates the impact of larger U.S. dairy product imports on the dairy economy of Wisconsin, examines economic adjustments that would occur in the Wisconsin and U.S. dairy economies, and helps to reconcile conflicting findings with respect to the extent the U.S. dairy economy would be depressed by larger dairy imports. Specific objectives of the study were to examine the economic effects on the Wisconsin and U.S. dairy industry of the following policies: (*a*) annual import level I (1.7 billion pounds of milk equivalent per year for 1976–80), consisting of net cheese imports of 170 million pounds, net butter imports of 5 million pounds, and net imports of other dairy products having a milk equivalent of 0.2 billion pounds; (*b*) annual import level II (3.2 billion pounds of milk equivalent per year for 1976–80), consisting of net cheese imports of 340 million pounds, net butter imports of 10 million pounds, and net imports of other dairy products having a milk equivalent of 0.2 billion pounds; (*c*) annual import level III (6.2 billion pounds of milk equivalent per year for 1976–80), consisting of net cheese imports of 680 million pounds, net butter imports of 20 million pounds, and net imports of other dairy products having a milk equivalent of 0.2 billion pounds; and (*d*) an-

[1] Such concerns were well founded. Import quotas now are authorized under Section 22 of the Agricultural Adjustment Act as amended to prevent imports of price-supported commodities from reducing the effectiveness of the price-support program or interfering with the operations of the program. Thus, if larger dairy imports were permitted, then presumably the U.S. dairy price-support program would need to be eliminated or revised, since without such changes the USDA at times would be forced to support world prices of dairy products.

nual import level IV, consisting of dairy imports equivalent to those considered by the USDA in its recent study of the open U.S. market policy. U.S. dairy imports under this policy equaled 12.2, 13.4, 10.5, 9.2, 8.0, and 6.7 billion pounds of milk equivalent for 1975, 1976, 1977, 1978, 1979, and 1980, respectively.

The composition of the hypothetical imports (i.e., the percentage of imports comprised of cheese, butter, and other dairy products) for import levels I, II, and III is similar to the actual composition of U.S. dairy imports in 1976. The composition of the imports in import level IV approximately is proportional to the composition of U.S. domestic consumption of butter, cheese, and other manufactured dairy products. Import level I represents a dairy import program similar to the one presently used. Therefore, findings for this policy serve as a benchmark against which results for other policies are compared.

Model Used in Study

A computerized, recursive simulation model that measures the effects of alternative manufactured milk import policies on farm milk prices, milk production, farm numbers, wholesale butter prices, wholesale cheese prices, and retail prices for milk, cheese, and butter was employed for analysis of the impacts of the four import levels. Most components of the model relate to the Wisconsin dairy industry, but the model has equations linking it to the U.S. manufactured milk industry, the USDA's manufacturing milk price-support program, and the Chicago regional federal milk order. The model contains forty-two equations (estimated behavioral equations and identities). Behavioral equations in the model containing one or more current endogenous variables were estimated by two-stage least squares. Other behavioral equations in the model were estimated by ordinary least squares. Readers wishing to obtain a detailed description of the model should consult Salathe, Dobson, and Peterson (pp. 4–15).

The sequence of operations performed by the quarterly model is outlined: (*a*) Base period values are read for the following variables: cow numbers, dairy herd replacement data, farm milk prices, farm wage rates, milk production per cow, grain concentrate prices, feeding rates, and number of dairy farms for Wisconsin; U.S. cheese and butter stocks, federal milk order data, Chicago wholesale butter prices, and Wisconsin wholesale cheese prices. (*b*) Current values are calculated or read for the following exogenous variables: U.S. all food price index, percentage of U.S. butter and cheese produced in Wisconsin, percentage of Wisconsin Grade A milk marketed under the Chicago federal milk order, class I price differential and class I price premiums for the Chicago federal order milk market, butter stocks, cheese stocks, disposable income, population, and transportation costs for the U.S.; farm wage rates, cattle prices, and grain concentrate prices for Wisconsin.

(*c*) Current values are predicted for feeding rates, milk production per cow, dairy herd replacement data, cow numbers, Grade A and Grade B milk marketings for Wisconsin; and (*d*) current values are predicted for the U.S. retail prices for butter and cheese, Chicago retail price for fluid milk, U.S. per capita consumption of butter and cheese, U.S. commercial disappearance of butter and cheese, and fluid milk sales under the Chicago federal milk order.

(*e*) Levels for the dairy import policy variables, U.S. net imports of butter and cheese, are specified; and then (*f*) equilibrium conditions are employed to predict current values for butter and cheese production for Wisconsin and the remainder of the United States, and the quantity of Grade A milk marketed under the Chicago federal milk order from Wisconsin and the remainder of the United States. (*g*) Current values are also predicted for the quantity of Wisconsin milk used for butter and cheese production, Chicago wholesale butter price, Wisconsin wholesale cheese price, Chicago federal order milk utilization percentages and producer milk prices, and the Minnesota-Wisconsin manufacturing milk price. (*h*) Current values are then predicted for the price of Grade A milk, price of Grade B milk and all milk price for Wisconsin, and the number of Wisconsin dairy farms. (*i*) Finally, steps (*b*) through (*h*) are repeated until the desired calculations have been completed.

An explanation of step (*b*) in the above sequence may be helpful. When the model is employed to compare the effects of an alternative dairy import policy with one that existed during a historical period, actual values for the variables listed in step (*b*) are read into the computer. Alternatively, if the model is used to predict how the effects of higher dairy im-

ports would differ from the effects of continuing dairy imports at present levels, then different values are entered at step (*b*). In the latter case, predictions of the values for the step (*b*) variables under a scenario where present import policies continue during the future period of interest are entered into the computer at step (*b*).

The model functions in such a way that, when increases in butter and cheese imports are simulated, this increases the available supply of manufactured dairy products in the United States. This supply increase, unless offset by a comparable simulated increase in butter and cheese purchases by the USDA under the price-support program, causes the model to establish the lower equilibrium wholesale butter and cheese prices required to clear the market of the increased domestic supplies of these dairy products. Such a change in wholesale butter and cheese prices for the current quarter t causes a reduction in farm milk prices for quarter t, a reduction in retail prices for fluid milk, butter, and cheese for quarter $t + 1$, and a reduction in milk production for quarter $t + 1$. The quantity of butter and cheese produced in quarter t is predicted to increase or decrease depending on the relative changes in the wholesale prices of butter and cheese in quarter t. The percentage change in milk, butter, and cheese production that occurs after the increase in dairy imports and the fall in wholesale prices is the same for Wisconsin and the remainder of the United States. In subsequent quarters, lower milk production tends to offset the impact of the increase in imports on farm, wholesale, and retail milk and dairy product prices. The following description of the model's equations suggests how changes that originate with changes in wholesale butter and cheese prices influence other variables in the system.

Retail prices of butter, cheese, and fluid milk for the current quarter are determined in the model by wholesale prices for these dairy products for the previous quarter, current transportation costs, and seasonal variables. Thus, the retail price equations reflect the passing along to retail customers of changes in transportation costs for the current quarter and wholesale price increases that occurred during the previous quarter. Per capita consumption of butter and cheese were determined by their current prices, per capita disposable income and, in the case of butter, the price of margarine.

Wisconsin Grade B farm milk prices for the current quarter are determined in the model by changes in wholesale cheese prices, wholesale butter price changes, Grade B milk prices lagged one quarter, and seasonal variables. Wisconsin farm Grade A milk prices are determined by price formulas similar to those used to compute blend prices under the Chicago federal milk order. The current Wisconsin all milk price, which influences milk production in succeeding quarters, is a weighted average of current Grade A and Grade B milk prices.

Adjustments in Wisconsin milk production occur under the model because of changes in milk production per cow, cow numbers, and the number of dairy farms. Milk production for the current quarter is predicted as the product of milk production per cow and the number of milk cows. The number of cows in Wisconsin is a function of the grain concentrate-lagged milk price ratio, the culled cow-lagged milk price ratio, the lagged number of cows and heifers kept as replacements, and seasonal variables. Milk production per cow is a function of grain fed per cow during the current quarter, milk production per cow lagged one quarter, and seasonal variables. Amount of grain fed per cow for the current quarter is determined by a grain-lagged all milk price ratio, amount of grain fed per cow during the previous quarter, and seasonal variables. The number of Wisconsin dairy farms is a function of the current Wisconsin all milk price, current farm wage rates, and current milk cow numbers.

Model Validation

The model was validated by determining how well it would reproduce the actual time paths of seventeen variables for 1969–73. Dairy product imports and USDA purchases of butter and cheese under the price-support program were set equal to their actual levels during the validation run. In the validation run, the model reproduced actual values for number of cows, milk production per cow, and number of Wisconsin dairy farms with an average error of less than 2%. The average error was between 2% and 3% for Grade A milk price, U.S. retail cheese price, cheese production for Wisconsin, cheese disappearance for the U.S., and the Chicago retail price of fluid milk. The average error also was relatively small (3% to 5%) for all other variables

except those relating to U.S. butter prices and Wisconsin butter production, which averaged from 7% to 11%. However, the errors in the butter price and butter production forecasts did not introduce large errors into predictions for related variables. The model also predicted accurately the relatively large increases in farm milk prices that occurred in 1973. Therefore, since the model reproduced actual time paths for most variables in the study with reasonable accuracy, no systematic biases appeared in results generated during the validation run and the coefficients of the estimated behavioral equations had correct signs, it was concluded that the simulation model was suitable to use for examining the effects of alternative manufacturing milk import policies.

Results

Procedures and assumptions involved in generating the results for import levels I, II, III, and IV should be noted. In the four experiments, purchases of manufactured milk products under the USDA's price-support program were set equal to zero in the model. This was done primarily because there was no way to accurately predict the amount and composition of these purchases for the full period of the experiments. Second, if plans II, III, and IV involving dairy imports of from 3.2 billion pounds to as high as 13.4 billion pounds of milk equivalent were operating, then price support purchases probably would be terminated, since otherwise the USDA would be involved in the costly business of supporting world dairy prices. Third, setting price-support purchases equal to zero for all experiments permitted results for import level I to serve as a benchmark run, which was comparable with the other runs except for the difference in dairy import levels.

The butter, cheese, and other dairy product imports for the computer experiments associated with import levels I, II, and III were established at the fixed levels associated with each of these import levels (e.g., manufactured dairy products equal to 0.8 billion pounds of milk equivalent per quarter for import level II) during the first quarter of 1976 and remained fixed at their respective levels through 1980. Simulated dairy imports associated with import level IV were fixed within years but varied from year to year during 1975–80.

In the experiments the following values and rates of increase were employed for exogenous variables. Wisconsin beef prices were projected to average $38.70 per hundredweight during 1976–80. Wisconsin farm wage rates, Wisconsin grain concentrate prices, U.S. transportation costs, U.S. disposable income, and the U.S. all food price index were projected to increase by 22.5%, 8.4%, 19.3%, 18.9%, and 29.6%, respectively, during 1976–80.

Normal caveats are applicable when interpreting the results. The results for the different import levels are presented in specific terms. However, given the uncertainties that can influence the exogenous variables (e.g., drought and unforeseen developments in international markets for feed grains), it is likely that the results will be more useful for showing the direction and approximate magnitude of adjustments under the different import levels and for gauging the relative impact of the different import policies than for predicting with great accuracy the economic impact of specific plans.

Import Level I

Milk prices, milk production, and cheese production for Wisconsin increase during 1976–80 under this hypothetical plan. The Wisconsin all milk price was projected to increase from $8.88 per hundredweight in 1976 to $9.57 per hundredweight in 1980, an 8% increase (table 1). Milk prices increase mainly because of a projected strong demand for cheese. Under import level I, milk production for Wisconsin is projected to rise from 17.5 billion pounds in 1976 to 19.2 billion pounds in 1980. This reflects the effects of moderately strong milk prices and beef prices, which fail to encourage any massive culling of cattle from dairy herds. Cheese production in Wisconsin plants would increase from 1.25 billion pounds in 1976 to 1.50 billion pounds in 1980, a 20% increase. Butter production in Wisconsin plants, on the other hand, continued to fall, declining 24% from 1976 to 1980. U.S. cheese and butter prices and fluid milk prices for Chicago were projected to increase by 13%, 1%, and 16%, respectively, during 1976–80, reflecting the impact of moderate increases in raw product costs and higher projected transportation costs. Sizable reductions in the number of dairy farms were projected to occur despite the small departure from present programs represented by this import plan. Dairy farm numbers were projected to decline from

Table 1. Simulated Values for Fourteen Variables at Three Different Levels of Imports, 1976–80

Variable	Import Level	Years				
		1976	1977	1978	1979	1980
Wisconsin all milk price ($/cwt.)	I	8.88	8.95	9.02	9.31	9.57
	II	8.56	8.80	8.95	9.26	9.53
	III	7.96	8.52	8.80	9.15	9.45
Wisconsin Grade A milk price ($/cwt.)	I	8.99	9.13	9.21	9.48	9.72
	II	8.70	8.98	9.12	9.42	9.67
	III	8.14	8.69	8.96	9.29	9.56
Wisconsin Grade B milk price ($/cwt.)	I	8.70	8.65	8.65	8.89	9.05
	II	8.34	8.48	8.56	8.82	9.00
	III	7.64	8.15	8.38	8.68	8.90
Percentage of Wisconsin milk produced as Grade A	I	62.8	64.1	67.6	72.6	78.7
	II	63.7	65.8	69.6	74.6	80.7
	III	65.5	69.2	73.7	78.9	84.9
Number of Wisconsin dairy farms (1,000)	I	49.5	46.4	44.1	42.0	39.6
	II	48.2	45.4	43.0	40.6	38.1
	III	45.6	43.4	40.7	37.8	35.0
Gross farm cash receipts from sale of Wisconsin milk (million $)	I	1,558	1,611	1,679	1,759	1,839
	II	1,486	1,545	1,614	1,692	1,771
	III	1,349	1,413	1,483	1,558	1,635
Wisconsin milk production (million lbs.)	I	17,544	18,003	18,618	18,892	19,219
	II	17,362	17,553	18,039	18,273	18,583
	III	16,943	16,590	16,858	17,025	17,299
Cheese production in Wisconsin plants (million lbs.)	I	1,251	1,303	1,371	1,437	1,504
	II	1,191	1,241	1,306	1,370	1,436
	III	1,072	1,114	1,175	1,236	1,302
Butter production in Wisconsin plants (million lbs.)	I	144	136	130	121	109
	II	148	138	131	120	109
	III	156	140	131	120	109
Cheese consumption in U.S. (million lbs.)	I	3,273	3,403	3,571	3,734	3,899
	II	3,294	3,417	3,578	3,738	3,902
	III	3,338	3,443	3,593	3,746	3,909
Butter consumption in U.S. (million lbs.)	I	729	691	661	612	554
	II	756	703	668	616	557
	III	807	724	680	623	563
Cheese price at retail in U.S. ($/lb.)	I	1.48	1.56	1.58	1.62	1.67
	II	1.44	1.53	1.56	1.61	1.66
	III	1.36	1.48	1.52	1.59	1.64
Butter price at retail in U.S. ($/lb.)	I	1.16	1.17	1.16	1.16	1.17
	II	1.13	1.15	1.15	1.15	1.16
	III	1.05	1.12	1.13	1.14	1.15
Fluid milk price at retail at Chicago (¢/½ gal.)	I	72.7	75.6	78.2	81.3	84.5
	II	72.3	75.3	78.0	81.1	84.5
	III	71.7	74.9	77.8	80.9	84.3

49,500 in 1976 to 39,600 in 1980, a 20% reduction. In summary, the figures suggest that many familiar production, consumption, and milk price trends would continue if a dairy import program similar to the one now employed were continued.

Import Level II

Import level II represents an intermediate dairy import policy (3.2 billion pounds milk equivalent) of the type that the Comptroller General identified as needing study. This level also was of interest since dairy imports under this plan are similar in size to actual U.S. dairy imports in 1973 and 1974, which totaled 3.9 billion pounds and 2.9 billion pounds of milk equivalent, respectively, and which were identified by the U.S. dairy industry as a major cause of a reduction in milk prices that occurred in 1974.

The model predicted that under import level II the Wisconsin all milk price, Grade A milk price, and Grade B milk price would be $8.56,

$8.70, and $8.34, respectively, in 1976 (table 1). This would have put the all milk price, Grade A price, and Grade B milk price $0.32 (3.6%), $0.29 (3.2%), and $0.36 (4.1%) lower, respectively, than under import level I.[2] Since dairy imports under import level II exceed those for import level I by 1.5 billion pounds, each billion pounds of milk equivalent of dairy imports under import level II over and above those for import level I would have reduced the Wisconsin all milk price, Grade A milk price, and Grade B milk price by $0.21, $0.19, and $0.24, respectively, for 1976. After three years, farm milk prices were projected to recover substantially. For example, by 1978, the Wisconsin all milk price under import level II was projected to rise to within $0.07 of the price for import level I, and by 1980 the Wisconsin all milk price was up to within $0.04 of the price under import level I. The recovery of milk prices occurred largely because milk production increased by a smaller amount under import level II than under import level I. This smaller increase in production reflected short-term supply response and the exit of farmers from the dairy business. The model projected that the increased imports under import level II would cause the number of dairy farms in Wisconsin to fall by an additional 1,500 (3.8%) by 1980 compared with farm numbers under import level I.

For the five years 1976–80, farm cash receipts from sales of Wisconsin milk were projected to be $338 million (4.0%) lower under import level II than under import level I (table 1). On a per farm basis, the cash receipts averaged 1.1% lower under import level II than under import level I during 1976–80.

Cheese production in Wisconsin plants would average about 5% lower under import level I than under import level II during 1976–80. However, U.S. cheese consumption would average less than 1% higher for 1976–80 under import level II than under import level I. Thus, the model forecasts some displacement of Wisconsin cheese by the imports, but little overall change in cheese consumption in the U.S. under import level II.

Consumer prices for cheese and butter in the U.S. and fluid milk prices in Chicago were forecast to average 1.4%, 1.3% and 0.3% lower, respectively, under import level II than under import level I during 1976–80. This result is perhaps not surprising since dairy imports under level II differ only modestly from those for import level I. Moreover, transportation cost increases that the model passes along to consumers in the form of higher prices offset much of the reduction in consumer prices that the increased dairy product imports would have produced.

The near doubling of imports under import level II compared with those for the benchmark run was projected to have a fairly moderate impact on farm milk prices in particular.[3] This was surprising in view of the large drop in farm milk prices that followed the increase in dairy imports in 1973 and 1974.[4] The explanation lies in factors other than dairy imports. In 1974, the impact of increased dairy imports was exacerbated by a recovery of milk production, some weakening of demand for dairy products, and an increase in butter imports at a time when butter prices already had begun to fall. In this study, a stronger market situation was forecast for 1976–80 than existed in 1974. The underlying market strength was forecast to more nearly offset the effects of increased imports on milk prices than was the case in 1974. This accounts for the price strength forecast for 1976–80 in the face of the larger dairy imports.

Import Level III

Import level III represents a larger departure from present import programs. However, this plan might be counted among the feasible plans, since both the USDA and the Comptroller General suggest that foreign suppliers (mainly those from EEC countries, Australia, and New Zealand) could supply the United States with as much as 6.2 billion pounds of

[2] The differential impact of the larger dairy imports under import level II on Grade A and Grade B milk prices is related to the uses made of these two grades of milk. Grade B milk meets only the sanitary standards for producing manufactured milk products. Grade A milk can be used to produce both fluid milk and manufactured milk products. Thus, as expected, the Grade B milk price was depressed to a greater extent by the larger dairy imports than was the Grade A milk price.

[3] However, the yearly average figures obscure the more pronounced reductions in farm milk prices that were projected to occur under import level II. For example, for the first quarter of 1976, the model projected that the Wisconsin all milk price would fall $0.51 below the comparable price for import level I. This was a $0.19 larger reduction than was projected to occur for the year 1976 as a whole.

[4] The Wisconsin all milk price declined from $8.70 in March 1974 to $6.77 in July 1974 (23%). The decline in the Minnesota-Wisconsin manufacturing milk price was from $8.15 to $6.29 (23%) during this same period. These reductions in farm milk prices occurred after U.S. dairy import quotas were relaxed to permit imports of 447 million pounds of cheese, 87 million pounds of butter, and 381 million pounds of nonfat dry milk during 1973 and early 1974.

milk equivalent in manufactured milk products yearly if U.S. dairy import quotas did not exist.

Projections were that under import level III, the Wisconsin all milk price, Grade A milk price, and Grade B milk price would be $7.96, $8.14, and $7.64, respectively, in 1976. This placed the Wisconsin prices for all milk, Grade A milk, and Grade B milk $0.92 (10.4%), $0.85 (9.5%), and $1.06 (12.2%) lower, respectively, than under import level I for 1976. Each billion pounds of milk equivalent of dairy imports under import level III over and above those for import level I would have reduced the Wisconsin all milk price, Grade A milk price, and Grade B milk price by $0.20, $0.19, and $0.24, respectively, for 1976.

As was the case under import level II, Wisconsin farm milk prices would recover substantially during 1976–80. For example, in 1980 the Wisconsin all milk price under import level III was only $0.12 less than the price for import level I. The impetus for the price recovery again stems from factors that reduce milk supplies. The number of Wisconsin dairy farms was projected to fall to about 35,000 in 1980 under import level III, which was a 12% greater drop in farm numbers than was projected for import level I. This decline in farm numbers plus supply adjustments by farmers remaining in business were projected to cause Wisconsin milk production to average about 8% less during 1976–80 under import level III than under import level I.

Farm cash receipts from sale of Wisconsin milk for the five years 1976–80 were projected to be $1.0 billion (12.1%) lower under import level III than under import level I (table 1). On a per farm basis, the cash receipts averaged 3.2% lower under import level III than under import level I during 1976–80.

Under import level III, the amount of cheese produced in Wisconsin plants would be substantially lower, but limited change was projected for U.S. cheese consumption and retail cheese prices. Cheese produced in Wisconsin plants would have been about 14% lower under import level III than under import level I in 1980. U.S. cheese consumption was 2.0% larger under import level III in 1976, but by 1980 this difference declined to 0.3%. Retail prices of cheese averaged about 4.0% lower over 1976–80 under import level III than under import level I. However, in 1980 the cheese price was only 1.8% lower under import level III than under import level I. The modest reduction in retail prices for cheese under import level III occurs because increased transportation costs and other factors largely offset the impact of larger dairy product imports on the retail prices.

Grade A milk production rises from 65.5% of the Wisconsin total in 1976 to 84.9% of the total in 1980 under import level III (table 1). Thus, in 1980 the percentage of milk produced as Grade A milk was projected to be 6.2% higher under import level III than under import level I. Under import level III, the Grade A milk price would increase by $1.42 during 1976–80 or by $0.16 more than the Grade B price. This widening of the differential of the Grade A milk price over the Grade B milk price accounted for the accelerated conversion to Grade A milk production. The increase in the percentage of Grade A milk would make more of Wisconsin's milk eligible for fluid markets. Such an increase might make Wisconsin's dairy economy less vulnerable to damage from dairy product imports and other factors that impinge most heavily on manufacturing milk prices.[5]

Import Level IV

The simulated dairy product imports under import level IV are identical in terms of milk equivalent to those considered by the USDA in the study of the open U.S. market policy. Thus, the imports equal 12.2, 13.4, 10.5, 9.2, 8.0, and 6.7 billion pounds of milk equivalent for 1975, 1976, 1977, 1978, 1979, and 1980, respectively. The decline in manufactured milk imports after 1976 reflects the assumption that dairy product exports to the United States would not be maintained at the 12 to 13 billion pounds of milk equivalent level because dairy product surpluses available for export from EEC countries would decline after 1976. In general, the open U.S. market policy represents a scenario where the United States would eliminate dairy price supports and import quotas, but other countries would be free to pursue dairy export policies of their own choosing. Consult the USDA's 1975 dairy import study for a full discussion of the assumptions relating to this policy.

Under import level IV, U.S. cheese imports

[5] However, reduced vulnerability is by no means certain. In order for the increase in proportion of Grade A milk production to have such an impact, it would be necessary for producers to find or develop new fluid markets for the larger supplies of Grade A milk.

ranged from 1,100 million pounds in 1976 to 550 million pounds in 1980, and U.S. butter imports ranged from 200 million pounds in 1976 to 100 million pounds in 1980. On a pounds of manufactured product basis, cheese imports comprised about 85% of the total and butter imports comprised 15% of the total. However, in terms of milk equivalent, cheese imports comprised only 68% of the imports and butter comprised 32% of the total under import level IV. Butter imports comprised a larger percentage of the dairy imports under import level IV than under import levels I, II, and III.

Comparison of Results

A new run was made with the model for 1975–80 with dairy imports set at level I (1.7 billion pounds of milk equivalent) to secure benchmark figures that could be compared with those reported by the USDA for these years. The new benchmark run was identical to that described earlier for 1976–80, except that actual values were used for the exogenous variables when possible.

The model predicted that the Wisconsin all milk price, Grade A milk price, and Grade B milk price under import level IV would be \$6.56, \$6.85, and \$6.05, respectively, in 1975. This would place the 1975 Wisconsin prices for all milk, Grade A milk, and Grade B milk \$1.47 (18%), \$1.37 (17%), and \$1.68 (22%) lower, respectively, than under import level I.

Each additional billion pounds of milk equivalent in dairy product imports in addition to the 1.7 billion pounds for import level I reduced the Wisconsin all milk price, the Wisconsin Grade B milk, and the Wisconsin Grade A milk prices by \$0.14, \$0.16, and \$0.13 per hundredweight, respectively, for 1975 as compared with prices under import level I. Thus, the additional units of dairy imports were projected to reduce farm milk prices by a smaller amount than was the case for import levels II and III. This occurred because of the different composition of the imports associated with import level IV. The model simulates a pattern of behavior under which dairy imports displace cheese and butter produced in Wisconsin and the remainder of the United States in proportion to their historical shares of production of these products. A relatively small share of the milk produced in Wisconsin has been processed into butter in recent years. In 1975, for example, only about 13% of the milk produced in Wisconsin was processed into butter, while 54% of the state's milk was processed into cheese. Thus, since butter comprised a larger percentage of the dairy imports under import level IV than under import levels II and III, the impact per billion pounds of milk equivalent imported on Wisconsin farm milk prices was projected to be lower under import level IV than under import levels II and III.

Wisconsin milk production would rise 4.1% from 16.3 billion pounds in 1975 to 17.0 billion pounds in 1980 under import level IV, which is substantially less than the 9.3% increase projected for import level I. The differing levels of milk production under the two plans are due, in part, to differences in the rate of decline in farm numbers. There were projected to be 5,100 (13%) fewer Wisconsin dairy farms in operation under import level IV than under import level I by 1980.

Consumer prices under import level IV exhibit a pattern similar to that under import levels II and III. For example, U.S. retail cheese and butter prices under import level IV for 1975 were 14% and 17% lower, respectively, than under import level I. However, by 1980 retail cheese and butter prices under import level IV were nearly the same as under import level I.

Comparison with the USDA's Results

The USDA projected that U.S. wholesale milk prices would have declined by 22% from \$8.94 under present programs to \$6.94 during 1975 under the open U.S. market policy. The comparable reduction predicted for import level IV in the present study was from \$8.03 to \$6.56 (18%) for 1975 (table 2). The USDA's figures imply that each additional billion pounds of milk equivalent imported over and above 1.7 billion pounds under present dairy programs would have depressed U.S. wholesale milk prices by \$0.19 per hundredweight in 1975. As indicated earlier, the comparable reduction projected for the Wisconsin all milk price was \$0.14 per hundredweight. The price reductions predicted by the two studies for 1975 under the open U.S. market policy are of similar size. Also the pattern of price recovery projected by the two studies was similar for 1975–80 (table 2). The moderately faster recovery forecast for Wisconsin farm milk prices occurs partly because Wisconsin milk production was projected to fall

Table 2. Milk Prices and Milk Production under the Open U.S. Market Policy

	USDA Study		This Study	
	U.S. All Milk Wholesale Price	U.S. Milk Production	Wisconsin All Milk Price	Wisconsin Milk Production
	% of Benchmark Values[a]			
1975	78.0	96.7	81.6	92.6
1976	88.0	91.6	91.0	84.1
1977	95.4	92.6	100.7	83.1
1978	99.0	93.0	101.3	85.2
1979	101.7	93.4	101.9	87.2
1980	104.9	93.8	103.4	88.5

[a] The benchmark figures for both the USDA study and the present study were developed with U.S. dairy imports of 1.7 billion pounds of milk equivalent per year.

by a larger percentage and to rebound less by 1980 than production for the United States as a whole under the open U.S. market policy (table 2).

The USDA projected that U.S. dairy farm numbers would decline by an additional 17,300 (8.5%) by 1980 under the open U.S. market policy as compared with the situation that would exist if present dairy programs were continued. This estimate was 4.5 percentage points smaller than the 13% reduction that was projected for Wisconsin for 1980 under import level IV. However, the two estimates appear to be consistent, since a moderately larger decline in farm numbers might be expected in Wisconsin where a larger percentage of the milk produced enters the production of manufactured milk products. Thus, both the present study and the USDA study suggest that sizable reductions in dairy farm numbers would result if an import program involving substantially larger dairy imports were adopted.

Summary and Implications

A computer experiment was conducted for 1976–80 with dairy imports established at 3.2 billion pounds of milk equivalent (designated as import level II). This experiment suggested that the 1976 Wisconsin farm all milk price would have been only about $0.32 (4%) lower under import level II than under a program with dairy imports at 1.7 billion pounds of milk equivalent. This projected reduction in farm milk prices was smaller than one that occurred in 1974 after actual U.S. dairy imports reached a level similar to that of import level II. In 1973–74, increasing milk production, weakness of the demand for some dairy products, and the timing of imports exacerbated the impact of dairy imports on domestic milk prices. In this study, more normal conditions were assumed to exist during the period of the experiment. Thus, the projected impact of the imports on farm milk prices was less. In general, the study suggests that imports in the 3.0 to 4.0 billion pounds of milk equivalent range would necessitate only moderate adjustments by the Wisconsin and U.S. dairy industries if such imports entered the U.S. when markets for dairy products were generally strong. Imports of this size could be disruptive and destabilizing under other circumstances.

A similar computer experiment was conducted for 1976–80 with dairy imports established at 6.2 billion pounds of milk equivalent (designated as import level III). This experiment indicated that 1976 Wisconsin farm milk prices under import level III would have fallen $0.92 (10%) below the level that would have prevailed in 1976 if dairy product imports had equaled 1.7 billion pounds of milk equivalent. Wisconsin all milk prices under import level III were projected to recover by 1980 to within $0.12 of those that would have existed if imports had been 1.7 billion pounds of milk equivalent, as farmers adjusted milk production and exited from the business. Wisconsin dairy farm numbers were projected to be 12% lower in 1980 under import level III than programs with imports equal to 1.7 billion pounds of milk equivalent. For 1976–80, total farm cash receipts from sale of Wisconsin milk were projected to be $1.0 billion (12%) lower under import level III than under the program with dairy imports at 1.7 billion pounds of milk equivalent.

The effects of operating under a hypothetical open U.S. market were simulated for 1975–80. Wisconsin's all milk price for 1975

under the open U.S. market policy would have been about $1.50 (18%) lower than the price for 1975 under a program where dairy imports equaled 1.7 billion pounds of milk equivalent. After about three years under the open U.S. market policy, Wisconsin farm milk prices would recover to levels near those that would exist under present dairy import programs. But this recovery would occur because many dairy farmers would be forced out of business. The study projected that within five to six years after adopting the open U.S. market policy the number of dairy farms in Wisconsin would fall about 13% below the number that would remain in business under present dairy import programs. Thus, these findings are consistent with the USDA's findings with respect to the impact of larger U.S. dairy imports equivalent to 25% of U.S. consumption of manufactured milk products. However, they tend to dispute claims of the Atlantic Council and Flanigan reports that the U.S. dairy industry would be required to make only small adjustments to accommodate these larger dairy imports.

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The Impact of Imports of Manufactured Milk Products on the U.S. Dairy Industry

Andrew M. Novakovic and Robert L. Thompson

Recent events have sparked a debate over the effects of increased dairy imports on the U.S. dairy industry. This study attempts to estimate these impacts via an econometric model of the U.S. dairy sector. The time paths of adjustment of consumption, production, and price of specific dairy products and raw milk are estimated under three alternative levels of manufactured milk product imports. The analysis suggests that much larger than historically "normal" import levels are required to bring about a substantial impact upon the dairy industry in the longer run.

Key words: agricultural policy, capital theory, dairy imports, dairy products, milk, trade policy.

Considerable debate on U.S. dairy policy has been generated by events in 1972–75. Section 22 of the Agricultural Adjustment Act authorizes the president of the United States to impose quotas on imports of manufactured dairy products. These quotas permit the domestic dairy price support program to function without supporting dairy prices throughout the rest of the world. From the late 1960s into the 1970s, dairy imports were restricted to about 1.5% of domestic consumption. This relationship quiescently persisted until, as production of milk declined, domestic prices of manufactured dairy products rose substantially above support levels in 1972. As prices continued to rise, the government repeatedly increased quotas on American cheese, butter, and nonfat dry milk for brief intervals over a period from 1973 to mid-1974. The quotas were raised above normal levels once for butter, twice for cheese, and five times for nonfat dry milk.[1] These quota changes resulted in the annual import levels reported in table 1. Although the exact effect of these increased imports is not known, it appears that the reduction of dairy product prices in early 1974 can be partially attributed to the high level of imports.

The Tokyo round of multilateral trade negotiations under the General Agreement on Tariffs and Trade (GATT) has also generated interest in the impact of changes in dairy trade policy on the U.S. dairy industry. In the negotiations, the United States is seeking reductions in barriers to its agricultural exports in the face of stiff opposition from the European Community (EC). Several studies of the impact of freer trade on U.S. agriculture indicate that, while an increase in exports could be expected for most agricultural products, an inflow of dairy products could be expected; i.e., the United States has a comparative disadvantage in manufactured dairy products (U.S. Congress; Johnson 1973, 1975; Vermeer et al.). Hence, it has been suggested that the United States should open its dairy market to the EC in exchange for greater access to the EC for American feed grains.

One concern is the potential impact of freer trade on the U.S. dairy industry. Johnson es-

Andrew M. Novakovic is a graduate research assistant and Robert L. Thompson is an assistant professor in the Department of Agricultural Economics, Purdue University.

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[1] The butter import quota was raised from about 0.7 million pounds to 84 million pounds from 1 November to 31 December 1975. The American cheese quota was raised from approximately 10 million pounds to 64 million pounds from 25 April to 31 July 1973 and again to 100 million pounds from 3 January to 31 March 1974. The nonfat dry milk quota of about 1.8 million pounds was raised to five different levels during five periods as follows: 25 million pounds from 30 December 1972 to 15 February 1973; 60 million pounds from 11 May to 30 June 1973; 80 million pounds from 19 July to 31 August 1973; 100 million pounds from 29 August to 31 October 1973; and 150 million pounds from 6 March to 30 June 1974.

Table 1. Raw Milk Production and Consumption and Imports of Selected Major Products, in Million Pounds

Year	Raw Milk Production	Fluid Milk Consumption	American Cheese		Butter		Nonfat Dry Milk	
			Consumption	Imports	Consumption	Imports	Consumption	Imports
1975	115,458	48,451[a]	2,134[a]	17	944	2	678	2
1974	115,553	47,603	2,234	112	908	2	838	115
1973	115,385	49,930	1,976	28	837	79	1,055	267
1972	119,904	50,810	1,909	15	858	2	848	2
1971	118,532	49,387	1,789	17	869	2	953	2
1970	116,962	49,794	1,709	16	893	2	953	2
1969	116,108	50,612	1,630	16	913	2	1,031	2
1968	117,225	51,740	1,679	16	974	2	1,029	2
1967	118,732	52,367	1,667	60	968	2	977	1
1966	119,912	54,120	1,549	50	1,047	2	1,005	3
1965	124,180	54,628	1,478	16	1,102	2	923	1

Sources: Butter and nonfat dry milk import levels obtained from USDA (1976). American cheese import levels obtained from various issues of the USDA *Dairy Situation*.

Note: All figures are reported in actual product weight except for fluid milk consumption, which is the milk equivalent on a fat-solids basis of all fluid milk products. The USDA (1965) reports the following factors for converting pounds of American cheese, butter, and nonfat dry milk into a raw milk equivalent on a fat-solids basis, respectively: 8.703, 21.702, and 0.216 pounds of raw milk equivalent per pound of dairy product.

[a] Estimated.

timates a possible reduction of 25% to 30% in domestic milk production as a result of free agricultural trade (1973). Buxton and Frick, on the other hand, suggest that imports would remain a very small percentage of domestic production and only slightly depress production and prices under conditions of free dairy trade. The U.S. Department of Agriculture study (1975) of the impact of imports on the U.S. dairy industry supports the more optimistic view reported by Buxton and Frick.

Previous studies of dairy trade policy appear to rely heavily upon professional familiarity with world and local dairy conditions. This has been backed up by use of coefficient estimates from existing models to predict the impacts of changes in dairy imports measured in terms of a milk-equivalent aggregate. Our research adds to the existing literature by estimating the time paths of adjustment within specific dairy product sectors to changes in the levels of individual manufactured product imports via one unified model.

The Conceptual Model

An annual simultaneous equations model of the U.S. dairy industry is used to analyze the domestic impacts of increased dairy imports.[2] The model describes the dairy industry at three market levels: farm, wholesale, and retail. Raw milk is produced at the farm level; supply and use of major manufactured dairy product groups are explained at the wholesale and retail levels. Five major product groups are considered: fluid milk products, American cheese, butter, nonfat dry milk, and frozen desserts. All other products, such as specialty cheeses, condensed, evaporated, and canned milk, and dried whey, are treated as a sixth "other products" category.

The price determination mechanism is consistent with the federal Milk Marketing Order system. The Minnesota-Wisconsin base price, specified as a function of manufactured product and input prices, determines the price of class II milk (the milk used in manufactured products). The class II price is, in turn, used to determine the price of class I milk (the milk used in fluid products). Class I and II prices are then weighted by the respective proportions of class I and class II utilization to obtain the farm level (blend) price. Class I and II

[2] Several dairy sector models cast in the system of equations framework are currently available in the literature (Goldman, Hallberg and Fallert, Prato). Nonetheless, this paper explores several areas that have not been examined in detail in previous dairy sector modeling. First, a significant departure from the recent literature is the disaggregation of the model in terms of the number of dairy products. Certain other pieces of research have focused on specific products, some in greater detail than that used in this work. Yet, no study has looked at the import question in the detail used herein. Furthermore, no simultaneous estimation of dairy product supply and demand including a complete dairy sector is known to be available or in use for the United States (Sahi and Harrington's Canadian model does have this feature). See Novakovic (appendix A) for a more detailed review of this literature.

prices also affect wholesale prices of fluid and manufacturing milk products. Finally, retail product prices are determined as a function of wholesale prices via margin relations.

The retail-wholesale components of the model are similar for each of the five major product groups. In general, the wholesale level consists of equations to determine production, year-end commercial stocks, year-end government stocks, and wholesale price. The retail level component of the model consists of equations to determine consumption and retail price. Of course, not all aspects of the general retail-wholesale component of the model apply to each product. Model details are specified in the econometric model presented below and in Novakovic.

The farm supply component of the model developed for this paper draws upon the work of Jarvis, Yver, Lattimore, and Freebairn and Rausser on the supply of beef. Their approach takes as a point of departure the fact that the cattle herd is a capital stock. Changes in that stock represent investment or disinvestment decisions. The capital value of a dairy animal equals the sum of the discounted values of the future stream of net income from the sale of milk produced by the animal, the salvage value of the animal, and the net value of future calves (the value of a heifer calf being determined by the discounted value of the milk it will produce and its future calves, and so forth *ad infinitum*) (Jarvis, p. 506). An increase in the expected price of milk raises the dairy animal's capital value. Therefore, farmers are expected to retain more animals for use in future production when there is an increase in the expected price of milk, *ceteris paribus*. Furthermore, for a given change in the expected price of milk, the change in the capital value of an animal is greater for those animals further from expected slaughter. Therefore, different retention behavior is hypothesized for each age cohort in response to a given change in the price of milk.

Imports of butter, American cheese, and nonfat dry milk are treated as exogenous. The supply of imported products is implicitly taken to be perfectly price inelastic due to the section 22 quotas on imports. This assumed exogeneity of imports has implications for the range of applicability of the model. This is demonstrated in figure 1.

Line *AB* represents the positively sloped excess supply curve of the rest of the world (for given exchange rates), and *CD* represents

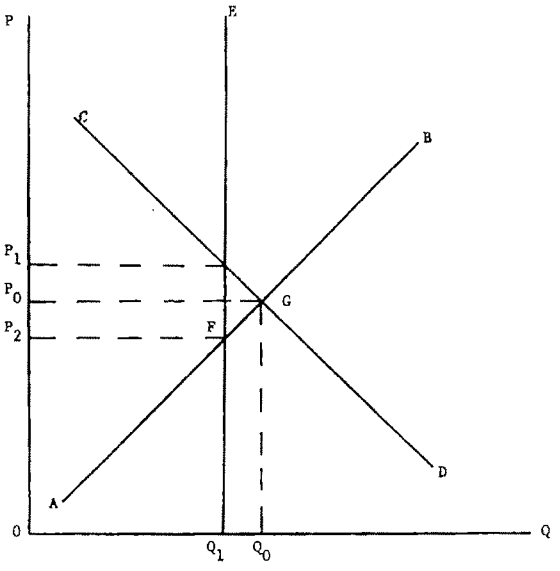


Figure 1. Domestic and world market price effects of a dairy import quota

the excess demand of the United States for a particular product.[3] Under free trade the equilibrium price is OP_0 and the quantity of imports is OQ_0. However, the imposition of a quota that limits imports to any level less than OQ_0, such as OQ_1, raises the domestic price to OP_1 and depresses the world market price to OP_2. With such a quota, the effective excess supply curve is *AFE*. However, treating imports as exogenous implies that the effective excess supply curve is Q_1E. This presents no problem as long as the quota is binding, i.e., *F* is left of *G*. If this assumption is violated such that *CD* intersects the effective excess supply curve along the segment *AF*, the model employed overstates the level of imports and understates the market price. The model would behave as if the quota was binding even though in reality it is not.

Such a problem is unlikely for import levels of about 1.5% of domestic consumption, the level at which imports were held in the United States prior to the increases in 1973 and 1974. Nonetheless, this discussion suggests a limita-

[3] The excess demand curve is the locus of the differences between the U.S. demand curve and the U.S. supply curve at given U.S. prices. The excess supply curve is computed as the locus of the differences between the supply curve and demand curve of the rest of the world and reflects the foreign (trade weighted) currency price. The price arguments of the U.S. excess demand function are denominated in U.S. dollars; hence, the price arguments of the excess supply curve of the rest of the world must be converted into U.S. dollars via an appropriate trade weighted exchange rate. Exchange rate changes or changes in foreign dairy price policy shift the foreign excess supply curve in U.S. dollar space.

tion of treating imports exogenously in this model (or any other model). When the level of imports is parametrically increased to estimate the domestic effects of increases in the quota, at some point a situation is reached in which the specified level exceeds OQ_0, and the analysis breaks down. To pinpoint quantity OQ_0, knowledge of the slope and position of the excess supply curve of the rest of the world, AB, is required. Estimation of the export supply structure of the rest of the world, a research effort of major proportions, is beyond the scope of the present study.

The Statistical Model

The parameters of the simultaneous equations model were estimated via two-stage least squares (2SLS) using annual data for 1955–74. Since the number of observations is less than the number of exogenous variables in the model, nine principal components, which explained at least 95% of the variation in the predetermined variables, were computed. These components were used in the first stage of the 2SLS procedure.[4] All estimated equations are linear. Variables in the model are defined in table 2.

Empirical results are reported in tables 3 through 8. Some experimentation was involved before the estimates shown were obtained. Due to a high degree of intercorrelation among many variables, it is difficult to

[4] Estimates obtained in this manner are statistically consistent, but little is known of their small sample properties. For a more detailed discussion, see Kloek and Mennes.

Table 2. Definition of Variables

Endogenous Variables

EC	$= NC_{t-1} + NH_{t-1} - NC$ (thousands of cows)
EH	$= NHC_{t-1} - NH$ (thousands of heifers)
NC	= Thousands of cows and heifers two years old and over kept for milk, on farms 1 January in year $t + 1$
NH	= Thousands of one- to two-year old heifers kept for milk cows, on farms 1 January in year $t + 1$
NHC	= Thousands of heifer calves under one year kept for milk cows, on farms 1 January in year $t + 1$
$PAC(R)$	= Average retail price of cheese in leading cities (¢/1/2 lb. package)
$PAC(W)$	= Average wholesale price of American cheese at Wisconsin assembling points (40 lb. block) (¢/lb., f.o.b.)
$PB(R)$	= Average retail price of butter in leading cities (¢/lb.)
$PB(W)$	= Average wholesale price of 92 score butter in Chicago (¢/lb.)
$PFM(R)$	= Average retail price of fresh, grocery milk in leading cities (¢/1/2 gal.)
$PFM(W)$	= Weighted average f.o.b. price of standard grade, 3.5% milk paid by dealers for distribution in fluid form ($/cwt.)
PI	= Average price received by farmers for milk eligible for the fluid market ($/cwt.)
$PIC(R)$	= Average retail price of ice cream in leading cities (¢/1/2 gal.)
$PIC(W)$	= Wholesale price index for bulk ice cream (1967 = 100)
PII	= Average price received by farmers for manufacturing grade milk ($/cwt.)
PMW	= Price received for Minnesota-Wisconsin 3.5% manufacturing grade milk ($/cwt.)
$PNFDM(W)$	= Manufacturer's average selling price of nonfat dry milk (¢/lb.)
PPC	$= \frac{QRM}{NC} \cdot 1{,}000$ (lb./cow)
PRM	= Average price received by farmers for all milk sold to plants ($/cwt.)
$QAC(RD)$	= Commercial civilian disappearance of American cheese excluding donations (millions of pounds)
$QAC(WS)$	= Production of American cheese (cheddar plus other American) (millions of pounds)
$QB(RD)$	= Domestic civilian disappearance of butter excluding donations (millions of pounds)
$QB(WS)$	= Production of butter (millions of pounds)
$QFD(RD)$	= Domestic civilian disappearance of net milk used in frozen dairy products (millions of pounds)
$QFD(WS)$	= Production of frozen dairy products (millions of pounds of net milk used)
$QFM(RD)$	= Domestic civilian disappearance of fluid milk and cream products excluding donations (millions of pounds of raw milk equivalent on a fat-solids basis)
$QFM(WS)$	$= QFM(RD) + DFM + QFM(M)$ (millions of pounds of raw milk equivalent on a fat-solids basis)
$QNFDM(WD)$	= Domestic civilian disappearance of nonfat dry milk (millions of pounds)
$QNFDM(WS)$	= Production of nonfat dry milk (millions of pounds)
QO	$= QRM - QFM(WS) - 10.0QAC(WS) - 21.2QB(WS) - 11.4QNFDM(WS) - QFD(WS)$ (millions of pounds of raw milk equivalent on a fat-solids basis)
QRM	= Production of all dairy products and fluid milk (millions of pounds of raw milk equivalent on a fat-solids basis)

Table 2, cont.

SAC(C), SB(C), SNFDM(C)	= Ending commercial stocks of American cheese (*AC*), butter (*B*), and nonfat dry milk (*NFDM*) (millions of pounds)
SAC(G), SB(G), SNFDM(G)	= Ending USDA stocks of American cheese (*AC*), butter (*B*), and nonfat dry milk (*NFDM*) (millions of pounds)
Exogenous Variables	
AFNFDM	= Utilization of nonfat dry milk in animal feed (millions of pounds)
AI	= Dairy cows bred artificially to dairy and beef bulls (percentage of *NC*)
CPIAF, CPIF, CPINF, CPISSP	= The consumer price index for all foods (*AF*), frankfurters (*F*), nonfoods (*NF*), and sugar and sweet products (*SSP*) (1967 = 100)
DIFFI	= *PI* − *PII* ($/cwt.)
DIFFII	= *PII* − *PMW* ($/cwt.)
DAC, DB, DFM, DNFDM	= USDA donations of American cheese (*AC*), butter (*B*), fluid milk products (*FM*), and nonfat dry milk (*NFDM*) (millions of pounds)
MAC, MB, MFD, MNFDM	= Imports of American cheese (*AC*), butter (*B*), frozen desserts (*FD*), and nonfat dry milk (*NFDM*) (millions of pounds)
PAC(S), PB(S), PNFDM(S)	= USDA purchase price of natural cheddar cheese grade A or higher (*AC*), butter grade A or higher (*B*), and nonfat dry milk, extra grade, spray process (*NFDM*) (¢/lb.)
PF	= Estimated value of concentrate rations fed to milk cows ($/cwt.)
PO	= Price of colored oleomargarine in leading cities (¢/lb.)
QAC(M), QB(M), QFD(M), QFM(M), QNFDM(M)	= Domestic military disappearance of American cheese (*AC*), butter (*B*), frozen desserts (*FD*), fluid milk products (*FM*), and nonfat dry milk (*NFDM*) (millions of pounds)
W(R)	= Average hourly earnings of production and nonsupervisory workers on private nonagricultural payrolls in grocery, meat, and vegetable stores ($/hr.)
W(W)	= Average hourly earnings of production and nonsupervisory workers on private nonagricultural payrolls in the dairy products industry ($/hr.)
T	= 1 for 1955, 2 for 1956, . . . , 20 for 1974.
XAC, XB, XNFDM	= Exports and shipments of American cheese (*AC*), butter (*B*), and nonfat dry milk (*NFDM*) (millions of pounds)
Y	= Total disposable personal income (billions of dollars)

Note: Sources of the data are listed in Novakovic, appendix E. In general, data were obtained from standard USDA and other governmental publications.

distinguish the relative effects of some explanatory variables. Several variables suggested as relevant by theory or logic are omitted from individual equations. The criteria for eliminating variables are primarily the consistency of each parameter estimate's sign with a priori expectations and the size of the standard error relative to the parameter estimate (see Novakovic, pp. 54–68, for details).

Several problems were encountered in es-

Table 3. Estimated Equations of the Fluid Milk Submodel

Retail demand:	$QFM(RD) = \underset{(8296.64)}{71602.274} - \underset{(25697.92)}{33470.2}\,\frac{PFM(R)}{CPINF} + \underset{(11718.7)}{11906.128}\,\frac{CPIAF}{CPINF} - \underset{(498.08)}{2665.673}\,\frac{Y}{CPINF}$
Retail margin:	$PFM(R) = \underset{(5.17)}{6.760} + \underset{(1.71)}{6.544}PFM(W) + \underset{(2.60)}{2.455}W(R)$
Wholesale margin:	$PFM(W) = \underset{(0.153)}{1.537} + \underset{(0.068)}{0.644}PI + \underset{(0.104)}{0.422}W(W)$
Market clearing:	$QFM(WS) = QFM(RD) + DFM + QFM(M)$

Note: In this and the following tables the numbers in parentheses are the standard errors of the coefficient estimates.

Table 4. Estimated Equations of the American Cheese Submodel

Retail demand:	$QAC(RD)$	$= -900.236 - \underset{(402.98)}{0.3200}\frac{PAC(R)}{CPINF} + \underset{(413.57)}{776.213}\frac{CPIAF}{CPINF} + \underset{(13.49)}{252.711}\frac{Y}{CPINF}$
Commercial stock:	$SAC(C)$	$= \underset{(110.13)}{171.730} + \underset{(5.28)}{7.934}PAC(W) - \underset{(6.51)}{3.325}PAC(S) - \underset{(0.212)}{0.2094}QAC(RD) - \underset{(0.354)}{0.3176}XAC + \underset{(0.268)}{0.5329}SAC(C)_{t-1}$
Government stock:	$SAC(G)$	$= \underset{(139.57)}{191.071} - \underset{(9.03)}{8.918}PAC(W) - \underset{(0.411)}{0.4240}SAC(C) + \underset{(11.05)}{8.975}PAC(S)$
Retail margin:	$PAC(R)$	$= \underset{(1.41)}{1.843} + \underset{(0.129)}{0.3604}PAC(W) + \underset{(2.61)}{10.550}W(R)$
Wholesale supply:	$PAC(W)$	$= \underset{(4.531)}{-10.698} + \underset{(0.0046)}{0.00412}QAC(WS) + \underset{(0.0803)}{0.10904}PB(W) + \underset{(0.594)}{8.752}PII + \underset{(1.53)}{3.372}W(W)$
Market clearing:	$QAC(WS)$	$= QAC(RD) + SAC(C) + SAC(G) + DAC + QAC(M) + XAC - MAC - SAC(C)_{t-1} - SAC(G)_{t-1}$

timating the retail-wholesale submodels. The most persistent, if not perplexing, problem was that the sign of the estimated coefficient of the price of cheese was contrary to a priori expectations. This suggests that factors causing rightward shifts in the demand for cheese, such as increasing preference for cheese, were not adequately accounted for by the set of explanatory variables originally specified. This hypothesis is supported by the fact that consumption has been increasing as the price of cheese has increased. Attempts to account for a shifting demand with various price and trend variables were not successful. Hence, the retail demand equation was reestimated with the cheese price coefficient constrained to equal −5,210.4, an estimate based on Boehm's cross-section demand study.[5]

[5] Boehm reports an own price elasticity of demand for American cheese of −1.44, based on an analysis of cross-sectional economic and demographic data collected during late 1972 and early 1973. Using comparably measured price and quantity data, the model for this paper was constrained to have the same price elasticity for the 1972–73 period as that computed by Boehm.

Table 5. Estimated Equations of the Butter Submodel

Retail demand:	$QB(RD)$	$= \underset{(278.53)}{1147.688} - \underset{(230.0)}{72.579}\frac{PB(R)}{CPINF} + \underset{(338.05)}{416.441}\frac{PO}{CPINF} + \underset{(342.58)}{402.308}\frac{CPIAF}{CPINF} - \underset{(36.56)}{75.458}\frac{Y}{CPINF} - \underset{(7.42)}{15.289}T$
Commercial stock:	$SB(C)$	$= \underset{(88.57)}{125.254} + \underset{(1.33)}{0.9954}PB(W) - \underset{(0.889)}{2.309}PB(S) - \underset{(0.055)}{0.0354}QB(RD) + \underset{(0.051)}{0.0179}QB(RD)_{t-1} + \underset{(0.024)}{0.0309}XB + \underset{(0.020)}{0.0008}XB_{t-1} - \underset{(2.62)}{0.1102}SB(C)_{t-1}$
Government stock:	$SB(G)$	$= \underset{(709.8)}{142.746} - \underset{(16.58)}{30.349}PB(W) + \underset{(7.51)}{4.669}SB(C) + \underset{(20.99)}{28.449}PB(S)$
Retail margin:	$PB(R)$	$= \underset{(6.49)}{33.358} + \underset{(0.127)}{0.4823}PB(W) + \underset{(0.860)}{7.337}W(R)$
Wholesale supply:	$PB(W)$	$= \underset{(30.63)}{9.189} + \underset{(0.011)}{0.00634}QB(WS) + \underset{(0.695)}{1.078}PAC(W) - \underset{(0.511)}{1.572}PNFDM(W) + \underset{(8.69)}{10.484}PII - \underset{(3.64)}{4.106}W(W)$
Market clearing:	$QB(WS)$	$= QB(RD) + SB(C) + SB(G) + DB + QB(M) + XB - MB - SB(C)_{t-1} - SB(G)_{t-1}$

Table 6. Estimated Equations of the Nonfat Dry Milk Submodel

Wholesale demand:
$$QNFDM(WD) = \underset{(361.24)}{410.526} - \underset{(6.03)}{18.373}PNFDM(W) + \underset{(9.73)}{2.585}PFM(R) + \underset{(2.49)}{6.535}CPIF + \underset{(0.263)}{0.238}Y$$

Commercial stock:
$$SNFDM(C) = \underset{(109.92)}{63.212} + \underset{(4.31)}{3.011}PNFDM(W) - \underset{(5.58)}{4.378}PNFDM(S) - \underset{(0.114)}{0.0781}QNFDM(WS)$$
$$+ \underset{(0.128)}{0.6463}AFNFDM + \underset{(0.040)}{0.0211}AFNFDM_{t-1} - \underset{(0.048)}{0.1808}SNFDM(C)_{t-1}$$
$$+ \underset{(0.606)}{0.6463}AFNFDM + \underset{(0.068)}{0.0211}AFNFDM_{t-1} - \underset{(0.515)}{0.1808}SNFDM(C)_{t-1}$$

Government stock:
$$SNFDM(G) = \underset{(221.97)}{-108.597} - \underset{(17.88)}{10.661}PNFDM(W) + \underset{(2.16)}{3.791}SNFDM(C) + \underset{(21.22)}{7.276}PNFDM(S)$$

Wholesale supply:
$$PNFDM(WS) = \underset{(5.69)}{-29.452} + \underset{(0.00215)}{0.00365}QNFDM(WS) + \underset{(1.61)}{15.218}PII - \underset{(1.95)}{5.912}W(W)$$

Market clearing:
$$QNFDM(WS) = QNFDM(WD) + SNFDM(C) + SNFDM(G) + DNFDM + QNFDM(M) + XNFDM + AFNFDM - MNFDM - SNFDM(C)_{t-1} - SNFDM(G)_{t-1}$$

Estimation of a reasonable own-price coefficient also proved to be a problem in the butter demand equation. In this case leftward shifts in demand were inadequately represented by the original set of explanatory variables. One likely factor explaining this shift is a change in consumer preference resulting from concern about the level of fat and cholesterol in the diet. Use of a trend variable results in a more plausible estimate of the price parameter.

The equation that determines the quantity of other products supplied is specified as an identity; hence, no estimation is required. It is necessary, however, to determine technical coefficients that would convert the product supply variables into raw milk equivalents on a fat-solids basis. Coefficients reported by the USDA (1965) are used to convert American cheese, butter, and nonfat dry milk quantities to raw milk equivalents on a fat-solids basis.

The results for the raw milk supply submodel reported in table 8 represent the most significant departure from previous dairy sector models. Other studies have found the price of beef to be an important variable explaining the quantity of milk produced (for example, Wipf and Houck). Such studies typically model the supply of milk as a single equation, expressing the quantity of milk supplied as a function of the price of beef. The price of beef is included in these models on the rationale that an increase in the price of beef causes farmers to reduce their herd size, which in turn reduces total milk production.

The estimated coefficients of the price of beef in the herd size equations suggest that an increase in the price of beef tends to increase the herd size at all age cohorts and thus increase current production of milk, as well as to provide the basis for future increases in milk production, *ceteris paribus*. This result is consistent with those obtained in analyses of the beef sector, which used a capital theoretic

Table 7. Estimated Equations of the Frozen Dessert Submodel

Retail demand:
$$QFD(RD) = \underset{(3,279.78)}{15,143.861} - \underset{(4,650.34)}{3,359.968}\frac{PIC(R)}{CPINF} + \underset{(1,089.02)}{2,228.731}\frac{CPISSP}{CPINF} - \underset{(4,460.13)}{7,276.373}\frac{CPIAF}{CPINF} + \underset{(498.09)}{520.791}\frac{Y}{CPINF}$$

Retail margin:
$$PIC(R) = \underset{(11.86)}{-16.026} + \underset{(0.094)}{0.7129}PIC(W) - \underset{(3.03)}{16.232}W(R)$$

Wholesale supply:
$$PIC(W) = \underset{(21.93)}{114.951} + \underset{(0.003)}{0.00003}QFD(WS) + \underset{(3.62)}{14.601}PII + \underset{(8.07)}{7.099}W(W)$$

Market clearing:
$$QFD(WS) = QFD(RD) + QFD(M) - MFD$$

Table 8. Estimated Equations of the Raw Milk Submodel

Production:	$QRM = NC \cdot PPC$
Productivity:	$PPC = \underset{(151.73)}{3461.821} + \underset{(64.46)}{20.321}PRM + \underset{(136.69)}{27.858}PF + \underset{(5.0)}{99.61}AI_{t-3}$
Cow numbers:	$NC = NC_{t-1} + NH_{t-1} - EC$
Heifer numbers:	$NH = NHC_{t-1} - EH$
Calf numbers:	$NHC = \underset{(663.06)}{1327.011} + \underset{(156.06)}{166.905}PRM + \underset{(13.72)}{36.009}PBF - \underset{(147.04)}{142.104}PF + \underset{(0.02)}{0.228}(NC + NH)_{t-1}$
Cow eliminations:	$EC = \underset{(1075.90)}{2851.739} - \underset{(253.23)}{412.854}PRM - \underset{(22.26)}{29.952}PBF + \underset{(238.59)}{337.884}PF + \underset{(0.03)}{0.157}(NC + NH)_{t-1}$
Heifer eliminations:	$EH = \underset{(155.55)}{542.829} - \underset{(38.54)}{16.501}PRM - \underset{(3.48)}{9.311}PBF + \underset{(37.40)}{34.493}PF + \underset{(0.02)}{0.022}NHC_{t-1}$
Blend price:	$PRM = \dfrac{PI \cdot QFM(WS) + PII(8.703QAC(WS) + 21.702QB(WS) + 0.216QNFDM(WS) + QFD(WS) + QO)}{QRM}$
Class I price:	$PI = PII + DIFFI$
Class II price:	$PII = PWM + DIFFII$
Minn.-Wisc. price:	$PMW = \underset{(0.361)}{-0.2489} + \underset{(0.0182)}{0.06216}PAC(W) + \underset{(0.0108)}{0.01716}PB(W) + \underset{(0.0132)}{0.0307}PNFDM(W) - \underset{(0.0909)}{0.14835}W(W)$
Other production:	$QO = QRM - QFM(WS) - 8.703QAC(WS) - 21.702QB(WS) - 0.216QNFDM(WS) - QFD(WS)$

formulation of the supply of beef. For example, Jarvis found that among Argentine beef ranchers an increase in the price of beef led to a short-run decrease in slaughter. An increase in capital value, brought about by a beef price increase, implies that it is profitable to retain animals longer, i.e., delay slaughter, and thereby increase future slaughter through short-run investment in the herd.

It appears that other studies have found a significant negative relationship between the price of beef and raw milk production because a rather high negative correlation exists between the price of beef and raw milk production (−0.78 in our data). In other words, studies using a single milk supply equation may have obtained the expected result for the wrong reason. The evidence from this study suggests that an increase in the annual beef price, *ceteris paribus*, tends to encourage short-run expansion of the dairy herd in response to the associated increase in the capital value of the dairy animal.

The Impact of Import Levels

In order to estimate the effects over time of changes in manufactured milk product import levels, the Gauss-Seidel technique is used to simultaneously solve the thirty-seven equations in the model.[6] The model is first solved for a base period, year 1, using the observed values of all predetermined variables. Next, import levels for American cheese, butter, and nonfat dry milk are parametrically varied from those in the base year, and the model is solved recursively for ten years (years 2 through 11) to estimate the time paths of adjustment to the specified changes in import levels. Lagged endogenous variables equal the appropriate values from the previous year. Imports are held constant at the levels established in year 2; i.e., changes are assumed to be once and for all. All other exogenous variables are maintained at their base period levels. The base year chosen is 1974, the last year for which data are available and the second of the two years in which dairy product imports are permitted substantially above their historical levels.

[6] The model presented in this paper contains several nonlinearities in the form of price ratios in demand equations and multiplication of endogenous variables to determine the supply of raw milk and the blend price. These nonlinearities preclude use of the more familiar matrix inversion technique of Theil and Boot to solve the system. A more detailed discussion of the Gauss-Seidel technique and its uses can be found in Heien, Matthews, and Womack.

Three different scenarios are evaluated. Scenario 1 investigates a return of import levels from their 1974 highs to the more or less normal levels observed in the earlier 1970s (about 1.5% of consumption). Specifically, scenario 1, the "normal" case, sets imports at 20 million pounds for American cheese, 2 million pounds for butter, and 2 million pounds for nonfat dry milk. An analysis of the impact of import levels twice that of the "normal" case is provided in scenario 2. This level is approximately the level that a USDA study (1975) suggests might initially result from free trade in dairy products. Specifically, the levels examined in the "twice normal" case are 40 million pounds for American cheese and 4 million pounds each for butter and nonfat dry milk. Scenario 3 is a "high" import quota case, examining the impact of continuing American cheese, butter, and nonfat dry milk imports at approximately the 1973–74 levels—100, 50, and 100 million pounds, respectively.

The simulated impacts of the import levels in each of the three scenarios on production, consumption, and prices of the various dairy products and raw milk are summarized in table 9. Selected results are also illustrated graphically to better display the basic trends and patterns of adjustment.

Figure 2 illustrates the adjustment made at the farm level in the price of raw milk. Following an initial increase, the price of raw milk in scenarios 1 and 2 converges to a level approximately equal to the base period level after three years. Continuation of relatively high import levels in scenario 3 results in a price that is 14¢ per hundredweight lower than the base price by year 11.

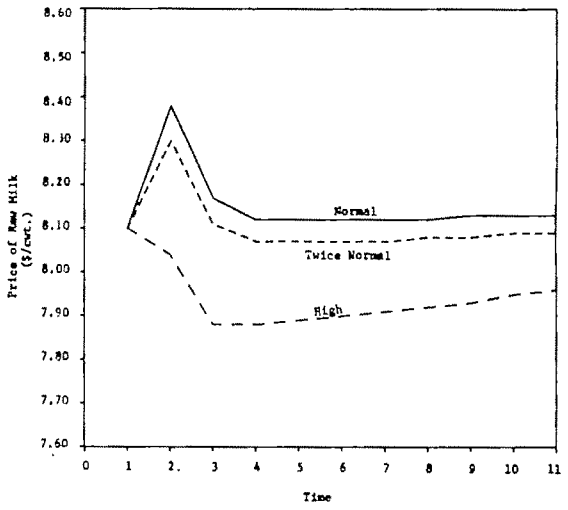


Figure 2. The effect of import levels on the price of raw milk

Milk production, shown in figure 3, initially increases but then decreases in the following years. By the eleventh year, production is down 2.7% under scenario 1 and 13.5% under scenario 3, when compared with the base year. (Adjustments in the dairy cow herd follow a similar pattern.)

Figures 4 through 6 illustrate the adjustments at the wholesale level. In general,

Table 9. Effects of Three Alternative Dairy Import Levels on Selected Endogenous Variables

Variable	Observed Values 1974	Projected Values, Scenario 1, by Year 1	2	3	11	Percentage Change Year 1 to Year 11	Percentage Change From Scenario 1, Selected Years: Scenario 2 2	Scenario 2 11	Scenario 3 2	Scenario 3 11
QFM(RD)	47,603	49,327	49,041	49,247	49,315	−0.02	0.16	0.12	0.70	0.52
QFM(WS)	51,753	53,477	53,191	53,397	53,465	−0.02	0.15	0.11	0.65	0.48
PFM(W)	8.64	9.06	9.24	9.11	9.07	0.11	−0.54	−0.44	−2.38	−1.87
PFM(R)	78.4	75.1	76.3	75.4	75.1	0	−0.39	−0.27	−1.97	−1.46
QAC(WS)	1,832	1,747	1,785	1,751	1,737	−0.57	−1.01	−0.75	−4.03	−2.82
QAC(RD)	1,767	1,682	1,646	1,672	1,681	−0.06	0.55	0.42	2.55	1.84
PAC(W)	79.9	82.8	85.6	83.6	82.9	0.12	−0.82	−0.60	−3.74	−2.90
PAC(R)	72.9	70.5	71.5	70.8	70.6	0.14	−0.42	−0.28	−1.68	−1.27
QB(WS)	962	944	969	967	968	2.54	−0.20	−0.31	−4.85	−5.06
QB(RD)	902	900	899	900	900	0	0	−0.11	0	−0.11
PB(W)	65.7	67.7	68.2	67.9	67.9	0.30	0.15	0.15	1.47	1.18
PB(R)	94.6	93.0	93.2	93.1	93.1	0.11	0.11	0.11	0.64	0.43
QNFDM(WS)	1,020	866	647	811	841	−2.89	2.16	1.55	−3.86	−3.09
QNFDM(WD)	802	744	680	726	742	−0.27	3.09	2.02	14.11	9.70
PNFDM(W)	58.6	62.0	65.7	63.1	62.1	0.16	−1.83	−1.29	−8.37	−6.44
QRM	115,553	119,827	122,265	121,709	116,612	−2.68	−0.26	−2.34	−1.13	−10.30
PPC	8,947	9,171	9,177	9,173	9,172	0.01	−0.02	−0.01	−0.08	−0.04
PRM	8.32	8.10	8.38	8.17	8.13	0.37	−0.95	−0.49	−4.06	−2.09
NC	12,916	13,065	13,323	13,268	12,714	−2.69	−0.24	−2.33	−1.05	−10.26
NH	3,625	3,587	3,359	3,402	3,360	−6.33	−0.03	−0.24	−0.18	−1.01
NHC	3,969	3,832	3,877	3,843	3,837	0.13	−0.31	−0.18	−1.44	−0.78

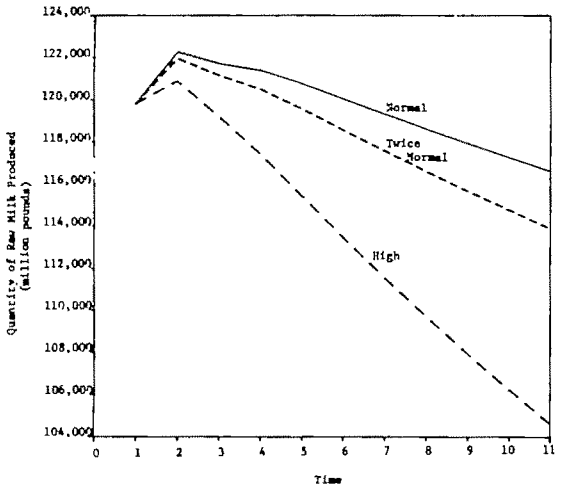


Figure 3. The effect of import levels on the production of raw milk

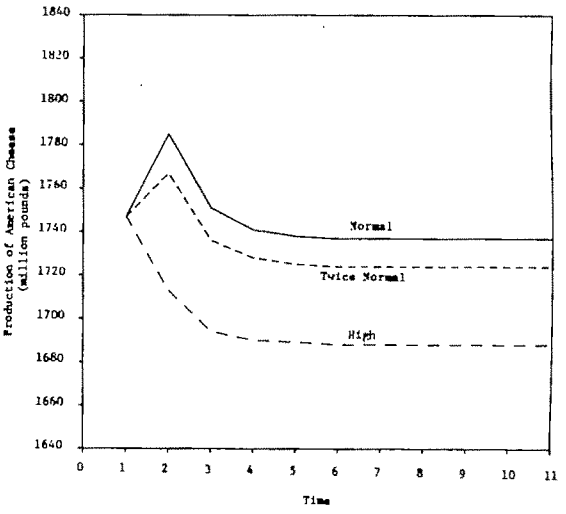


Figure 5. The effect of import levels on the production of American cheese

wholesale prices and production tended to be higher with lower import levels, as would be expected. Nevertheless, there were several exceptions. Figure 4, which shows the changes in the quantity of fluid milk produced, illustrates the pattern of the production response in both the fluid and frozen dairy products sector. Production is higher in all periods under scenario 3 than under scenario 1. These results seem to occur because of the changes in class I and II prices. As these prices decrease, production of fluid milk and frozen desserts is stimulated. This implies that raw milk is diverted to the production of nonimported products as manufactured product imports increase.

Production adjustments in the cheese and butter sectors are represented by the results for American cheese shown in figure 5. In both cases, higher imports lead to lower production. However, nonfat dry milk production responds somewhat differently. Nonfat dry milk imports in 1974 total 115 million pounds. In scenarios 1 and 2, import levels are set much below this level at 2 and 4 million pounds, respectively. At these low levels, production under scenario 2 is higher than that under scenario 1. In scenario 3, in which nonfat dry milk imports equal 100 million pounds, import levels are so high that they bring about lower production levels than those for the

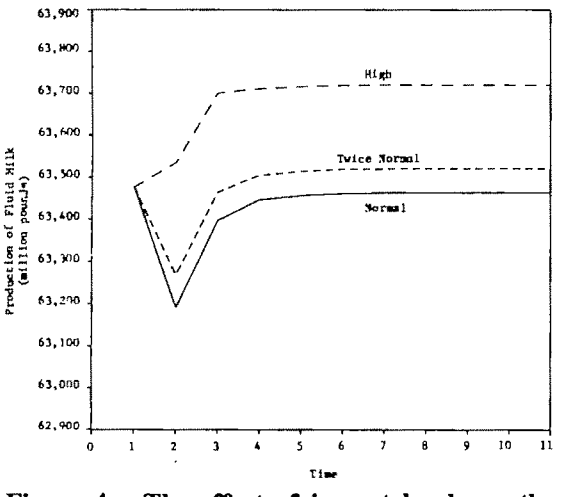


Figure 4. The effect of import levels on the production of fluid milk

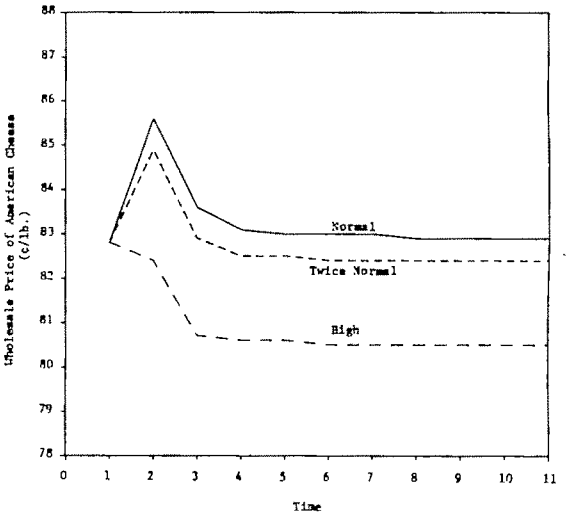


Figure 6. The effect of import levels on the wholesale price of American cheese

"normal" case. This response can be explained as follows. Cross-price effects are also found to be insignificant in the nonfat dry milk supply equation. Thus, as the class II price decreases relatively more under scenario 2 than under scenario 1, nonfat dry milk production is stimulated in the same way as fluid and frozen dairy product production. However, imports are so high under scenario 3 that the own price effect dominates the effect of cheap input prices and thus leads to a lower level of nonfat dry milk production.

Wholesale price responses, illustrated by the price of American cheese in figure 6, are similar for all variables except butter. The wholesale price of butter is lower at lower import levels apparently because a cross-price effect is present in this case. Specifically, the coefficient of the price of nonfat dry milk as estimated in the butter supply equation reflects a complementary relationship between nonfat dry milk and butter. Thus, the higher price of nonfat dry milk at low import levels stimulates butter production, which leads to a lower butter price.

At the retail level, increased imports are generally associated with increased consumption and decreased prices. The response in the butter sector is just the opposite, i.e., consumption decreases and price increases. Because the wholesale butter price is higher with higher imports, the retail price increases, and thus consumption decreases. In any case, there is practically no difference in the price or consumption of butter among the three scenarios. In each, butter consumption fluctuates between 900 and 899 million pounds.

The impacts of changes in import levels on the consumption and retail price of American cheese are illustrated in figures 7 and 8, respectively, and are representative of the impacts on the remaining dairy products.

The difference in the magnitudes of the endogenous variables between scenarios 1 and 2 seldom exceeds 1% in any given year (table 9). The differences between scenarios 1 and 3 are typically in the range of 1% to 5%. Nonfat dry milk production, consumption, and price, raw milk production, the number of cows, and other product production tend to be the more volatile variables, especially other product production.[7] Furthermore, following some

[7] Since the quantity of other products produced is computed as a residual, it is subject to the largest potential prediction error. Hence, the larger differences between scenarios 1 and 3 (up to 70% by year 11) are not surprising.

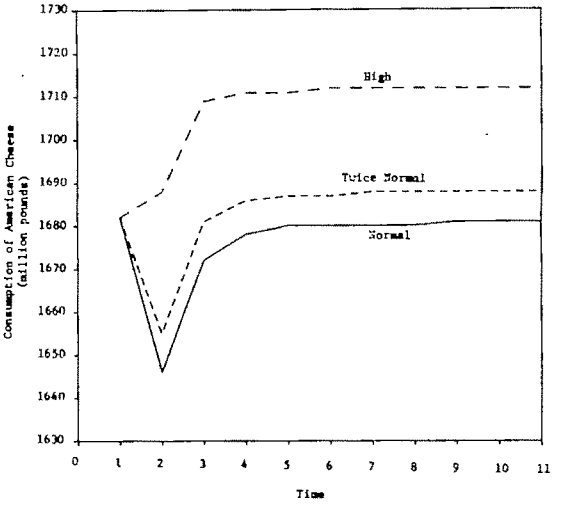


Figure 7. The effect of import levels on the consumption of American cheese

initial fluctuations, most variables under scenarios 1 and 2 tend to converge to a level approximately equal to the base year value by year 4. Only production of butter, nonfat dry milk, other products and raw milk, and the number of cows and heifers deviated more than 1% from the base year by the eleventh year under scenario 1.

Several facts should be borne in mind when comparing specific results. One is that the ratio of base year import levels to those under the three scenarios varies markedly for butter, American cheese, and nonfat dry milk. American cheese imports under scenarios 1 and 3 equal about 18% and 90% of base year American cheese imports, respectively. Nonfat dry

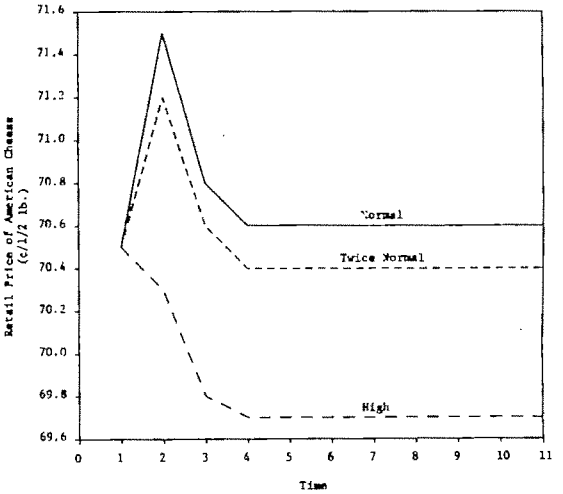


Figure 8. The effect of import levels on the retail price of American cheese

milk imports under scenarios 1 and 3 equal about 2% and 87% of base year nonfat dry milk imports, respectively. Imports of butter had already returned to historically normal levels by 1974, the base year. Thus, butter imports under scenarios 1 and 3 are 100% and 2500% of that in the base year, respectively. This suggests that the impact of a change in imports on the different dairy products within any scenario should not be expected to be identical.

The different ratios of imports to consumption of the various dairy products under the three scenarios also affect interproduct comparisons. For example, imports of American cheese, butter, and nonfat dry milk under the "high" import case represent 4.7%, 5.3%, and 14.7% of observed consumption, respectively. With this in mind, it becomes apparent why three of the variables that deviated most from scenario 1 values under scenario 3 are nonfat dry milk production, consumption, and price.

Implications

Rather large changes in import levels are required to bring about substantial impacts on the dairy industry. As table 9 illustrates, the difference in the magnitudes of almost all endogenous variables under "normal" and "twice normal" import levels is less than 1%. Only when imports are a much larger proportion of consumption, as in scenario 3, does a significant impact upon the dairy sector appear. For example, in scenario 3, the price of raw milk is 17¢ or 2% lower than that in scenario 1 by the eleventh year. Even at the widest divergence between raw milk prices in scenarios 1 and 3 (in year 2), the difference is only 4% or 34¢.

Although comparisons of these results with those obtained in other studies are difficult because of the different techniques and models used, these results suggest a more modest impact than that derived in other studies. The USDA (1975) estimates a decline in the raw milk price of 18¢ per hundredweight for each additional billion pounds of aggregate dairy imports measured in terms of milk equivalents. Using this value, the level of imports under scenario 3 should result in a raw milk price that is about 30¢ lower than that in scenario 1. This is about the same as our computed short-run response in years 2 and 3, but it is much greater than the computed difference by year 11. Using "open U.S. market" import levels from the USDA study, Salathe, Dobson, and Peterson estimate that an increase in aggregate imports of one billion pounds is accompanied by an 11¢ decrease in the price of raw milk in Wisconsin.[8]

When comparing these results, several factors should be kept in mind. The USDA and Salathe, Dobson, and Peterson studies are based on imports much higher than those under current programs. The "open U.S. market" policy assumes aggregate imports representing 25% of manufactured milk consumption; this compares with an average import of about 1% to 2% during the last twenty years. Such high levels were not examined in this study because it was felt that extrapolating so far beyond the range of the data would severely strain the credibility of the results. In addition, as discussed in connection with figure 2, one runs the risk of setting imports above the level that actually would enter the market under free trade, in which case erroneous implications would result.

The aggregate impacts of changes in imports are unlikely to be distributed uniformly over the milk-producing regions of the United States. Quite different impacts of increased butter and cheese imports would likely be felt by dairy farmers in Wisconsin, New York, Iowa, and California.[9] In regions characterized by different alternative uses for their resources, the fixity of capital and labor is likely to be an important factor determining the nature of the response and the ability of the farmers to respond. Asset fixity may also be an important element affecting the rate of adjustment of the dairy processing sector. Were data on the capital stocks of the dairy farming and dairy processing sectors available, an analysis of their adjustments could be cast in the same capital theoretic framework as were dairy herd adjustments in this model.

Perhaps an even more basic question than that of the regional impacts is the question of just how high dairy imports would be under a freer dairy trade policy. This paper does not

[8] Since Wisconsin produces a relatively much larger proportion of manufactured milk than the United States as a whole, it is plausible that the impact of dairy imports would be more harsh in Wisconsin than in most of the rest of the country. In that case, Salathe, Dobson, and Peterson's results would imply that the aggregate impact on the U.S. market would be much less than that predicted by the USDA (1975).

[9] Salathe, Dobson, and Peterson have investigated that impact of dairy imports on Wisconsin. To estimate the differential impact of dairy import policy on various regions of the United States, a regional model of the U.S. dairy industry would be required.

attempt to answer this question. To do this would require structural estimates of export supply functions for butter, cheese, and nonfat dry milk for each of the important dairy exporting countries. The relationship between prices and excess supplies of dairy products in the rest of the world remains one of the most critical questions in dairy trade policy. To the authors' knowledge, no rigorous modeling efforts exist in the literature that estimate these critical relations, and there is little agreement on the likely orders of magnitudes of price-quantity relationships.

As indicated previously, one deficiency of this U.S. model is that it applies only to import levels below those which would be experienced under free trade, i.e., at levels below OQ_0 in figure 1. Without more information concerning the slope and position of the excess supply relations of the important dairy exporting countries, that level cannot be estimated with much certainty. To this end the authors suggest the need for modeling efforts for the dairy sectors of at least the European Community and Oceania.

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Notes

Technically Efficient Movement Patterns and Manufacturing Plant Locations under Regionally Coordinated Milk Assembly

William T. Boehm and M. C. Conner

The organization and subsequent marketing activities of regional dairy producer cooperatives in the United States have recently been the subject of public debate (Hudek, Hutt). The debate has centered on what role, if any, such regional organizations should be permitted in the assembly, movement, and processing of raw milk. To date, these public discussions have focused attention on what effect, if any, the regional dairy cooperatives have had on the level of raw milk prices. A related question within the context of these public sector concerns is how the activities of these regional organizations affect the technical operating efficiencies (i.e., the costs) involved in performing the raw milk assembly function. For the most part, this question has been ignored. It has been simply assumed that an atomized milk assembly system would also be technically efficient.

The research reported in this paper is an attempt to determine the seasonal raw milk movement patterns and manufacturing plant locations that would minimize the combined costs of assembling all raw milk produced in a specific geographic region and processing the raw milk not delivered to bottling plants for fluid use into a manufactured product form. It is hypothesized that if (*a*) the economies of size in manufactured product processing are substantial relative to transportation costs, so that the optimal number of such plants "needed" within the region is small, and (*b*) the optimal movement patterns from production areas to all plants in the region are seasonal in nature, then cost minimization for the region can only be accomplished with a relatively high level of coordination in the handling of raw milk and within an organizational structure that allows individual producers to be indifferent as to the ultimate disposition of their production.

The analysis is conducted within the southeastern region of the United States, roughly including the nine-state area east of the Mississippi River and extending south from Ohio and West Virginia. A regional dairy producer cooperative in the area makes *ex ante* commitments to deliver specified quantities of fluid eligible raw milk to the already existing bottling plants in the region. The raw milk produced but not sold for use in the fluid form is then processed into cheese, butter, or powdered milk by either the cooperative or proprietary handlers. Thus, taking as given the number, size, and location of the fluid bottling plants, the research problem becomes one of determining the seasonal movements for all milk and the number, size, and location of "hard-product" manufacturing plants that will minimize movement and processing costs. Obviously, the size and location of the manufacturing plants cannot be determined without simultaneously considering optimal movement patterns to the fluid bottling plants.

William T. Boehm is an assistant professor of agricultural economics and M. C. Conner is a professor of agricultural marketing at Virginia Polytechnic Institute and State University.

Research Procedures and Data

Mathematically, this research problem can be stated as a linear programming problem, and the solutions can be obtained using a modified version of the transportation algorithm. For this study, the algorithm is modified to permit transshipment and to incorporate approximately the effects of nonlinear economies of size in raw product processing.[1] Readers not familiar with the mechanics of these modifications or their effect on the nature of the solution obtained may refer to the referenced publications by King and Logan or Roe. The solution system developed for this study has been documented and is available from the authors (Boehm).

Grade A milk production by county and fluid milk deliveries to ninety-seven major fluid bottling centers in the region are developed for October 1974 and May 1975.[2] Counties in the relatively dense milk production areas of the region are identified as separate production sources. Milk from several

[1] The use of a nonlinear solution method would have been preferred. Practical considerations regarding both the computing time and storage capacity required for such a solution largely prohibit their use, given the level of disaggregation desired. Furthermore, since plants tend to operate at capacity, it is doubtful whether using nonlinear procedures would result in any significant changes in the final solution.

[2] During 1975 raw milk was packaged in roughly 200 plants in the study area. The quantities packaged in these plants were aggregated for ninety-seven geographic areas. In Kentucky, for example, eighteen plants were packaging fluid milk in 1975, but five of these plants were at locations with more than one plant. Therefore, only thirteen bottling centers are identified for Kentucky.

counties is aggregated to form a single raw milk source in the lower density production areas. While the bottling center locations are taken as given, thirty-one geographically dispersed sites are chosen as potential locations for the manufacturing plants.

Three transportation cost functions are developed to reflect the cost differentials associated with variations in the terrain and production density and in order to incorporate certain of the limitations imposed on milk movement by its highly perishable nature. The functions used for the study and a detailed description of the procedures employed in their development are contained in the report by Boehm and Conner.

Processing cost functions are developed using an engineering cost approach for both cheddar cheese and combination butter and powdered milk plants. The detailed procedures followed in deriving these relationships are reported by Conner, Boehm, and Pardue. The functional relationships, estimated by ordinary least squares, express total processing costs for each plant type as a function of the monthly quantity of raw milk processed and are as follows: $TCC = 42{,}466 + 0.5292q$, $R^2 = 0.997$, and $TCP = 49{,}730 + 0.4788q$, $R^2 = 0.998$, where TCC is the total cheese processing costs (dollars per month), TCP is the total butter-powder processing costs (dollars per month), and q is the quantity of raw milk processed (hundredweight per month).

These total cost functions have the same interpretation as those used by Stollsteimer. The intercept is interpreted as the minimum average annual long-run cost of establishing and maintaining a plant. The slope coefficient is an estimate of the marginal processing cost.

Monthly raw milk production levels allowed for the synthesized cheese plants range from 32,250 hundredweight for the minimal practical operation to 255,850 hundredweight for the largest plant operating at maximum capacity. Operating levels permitted for the combination butter and powder plants are from 34,060 to 331,000 hundredweight of raw milk per month.

The level of disaggregation proposed for the problem prohibits the use of a solution procedure that would simultaneously incorporate the effects of seasonality in production and in fluid consumption in determining the optimal number, size, location, and type of manufacturing plant (either cheese or combination butter and powder) as well as the associated optimal seasonal milk movement patterns to all plants in the region. Therefore, a solution to the cost-mimimization problem is obtained using the transportation algorithm, the data described above, and two research phases. In phase one, milk movement patterns to fluid bottling centers and optimal manufacturing plant locations are obtained for four independent and static situations. A movement pattern and plant location set is obtained for each season, May and October, given the assumption that all plants manufacturing excess Grade A milk in the region are cheese plants. Two additional solutions are obtained by assuming that, in each season, all manufacturing plants are combination butter and powder operations. These solutions permit the identification of a least-cost plant set for use in phase two. In that phase, least-cost movement patterns and operating levels are determined for the optimally located plant set in an effort to identify the movement patterns to all plants and the operating levels for the manufacturing plants that would result in minimizing the total costs of raw milk movement and manufactured product processing throughout the year.

Phase One Results

Manufacturing plant locations and their associated operating levels for the two product types in both May and October are summarized in table 1. The impact of processing economies on the ultimate

Table 1. Optimal Manufacturing Plant Location Sets During May and October

	Cheese		Butter-Powder	
	May	October	May	October
	Cwt. Processed			
Plant ID and location				
102, Kentucky	255,850	255,850	331,000	331,000
112, Tennessee	255,850	170,899	331,000	5,749
115, Tennessee	164,524	—	—	—
121, N. Carolina	255,850	—	194,924	—
128, Louisiana	255,850	—	331,000	—
Total				
Milk to manufacturing plants	1,187,924	426,749	1,187,924	426,749
Milk to bottling centers	7,372,076	7,173,251	7,372,076	7,173,251
All milk	8,560,000	7,600,000	8,560,000	7,600,000
Cost summary ($)[a]				
Processing cost/cwt.	0.708	0.728	0.646	0.712
Assembly cost/cwt.	0.348	0.356	0.350	0.357

[a] Processing costs are for the manufactured product only. Assembly costs include the movement of raw milk used for both fluid bottling and manufactured product processing.

number of plant sites selected is obvious. Regardless of the season, manufacturing plants tend to operate at the maximum capacity permitted for the type of plant being considered. Plants are located in those areas where milk production is dense relative to fluid consumption.

In May, only five plant sites are selected by the model for manufacturing excess Grade A milk into cheese. Four of these plants operate at maximum capacity. In October, only two plants are needed to process the available milk into cheese. Average assembly costs for all milk increase from $0.348 to $0.356 when only two manufacturing plants are operated.

Average processing costs for combination butter and powder plants are $0.065 per hundredweight higher in October than in May. Less than 65% of the required capacity is utilized to process the raw milk available for manufacturing in that month. In May, almost 90% of the available capacity is utilized to process the available milk. Average assembly costs for all milk increase $0.007 per hundredweight from May to October, reflecting the increased movement necessary when fewer manufacturing plants are operated.

Long-haul movements through transfer stations are avoided in the cost-minimizing solutions obtained in phase one. In almost all cases, transport costs are less than $0.50 per hundredweight. When possible, milk production from nearby sources is used to satisfy fluid consumption requirements. In those areas where local production is not adequate, additional raw milk for fluid bottling is obtained by a process of "dominoing" milk toward the bottling center in a series of 100 or 150 mile movements. Milk for the manufacturing plants is also obtained from nearby production sources and not by transporting "excess" milk from widely separated fluid consumption areas. While the use of transfer stations is avoided by the model, neither the four-day fluid processing schedules nor the weekly or daily market shocks, which often necessitate raw milk storage facilities, are taken into account. Providing such facilities would undoubtedly increase total costs. Where they would be located is a researchable question, of course, but is not considered in this study.

Phase one results also indicate the importance of considering explicitly the seasonal variations in both production and consumption when solving for least-cost milk movement patterns. The least-cost pairing of milk sources with specific plants changes substantially from May to October. In the high production spring season (May), milk for fluid bottling is obtained from nearby sources generally moving milk toward the northern markets, where the milk in excess of fluid requirements could be most economically aggregated for manufacture. In October, the least-cost pairings indicate that milk for fluid bottling, while still coming from nearby sources, is transported in a north-to-south direction. In total, milk from only 174 of the 290 production sources goes to the same plant in both seasons. Quantities delivered indicate even more variability.

Phase Two Results

Information gained from these phase one solutions is used to select the locations and plant types for a single plant set, so that least-cost movement patterns and operating levels could be obtained for the entire marketing year. The five locations identified in table 1 are chosen as sites for the optimal manufacturing plant set. Three of these locations, 102, 112, and 128, are designated for cheese plants. The other two, 115 and 121, are designated as locations for combination butter and powder plants. This plant set provides the model with sufficient capacity to process all the milk available during the high production May season without substantial excess capacity and, implicitly recognizing the revenue considerations, also contains a combination of both cheese and butter-powder plants. The cheese plants are located in those areas that would permit, in so far as is possible, continual operation throughout the year. While per unit costs at high volumes of operation are lower in the butter and powder plants, the critical role skilled labor plays in the successful operation of a cheese plant and the need to meet market commitments from the current production of some cheeses persuade us to choose this alternative.

The least-cost milk movement patterns to all plants and the implied operating levels for each of the manufacturing plants in the specified plant set are determined for each season. The results of these analyses are summarized in table 2. Two of the cheese and one of the butter and powder plants operate at or near the maximum capacity permitted

Table 2. Impact of Seasonal Variation in Milk Availability on Processing

	Product Type	Volume Processed (Cwt.) May	October
Plant ID and location			
102, Kentucky	Cheese	250,379	133,900
112, Tennessee	Cheese	128,706	8,775
115, Tennessee	Butter-powder	318,347	113,727
121, N. Carolina	Butter-powder	234,642	100,347
128, Louisiana	Cheese	255,850	0
Cost summary ($)[a]			
Processing cost/cwt.		0.697	1.034
Assembly cost/cwt.		0.348	0.353

[a] Processing costs are for the manufactured product only. Assembly costs include the movement of raw milk used for both fluid and manufactured product processing.

for that product type during the May period. The average per unit cost of processing during that period is $0.697 per hundredweight. In October, none of the five plants operate at capacity. The cheese plant at location 128 actually ceased operating entirely. The other four plants operate at between 30% and 50% of capacity. Assuming the intercept of the cheese processing cost function is a reasonable estimate of fixed costs, per unit costs of processing the 43 million pounds of raw milk not consumed in the fluid form during October would be approximately $1.034. That represents almost a $0.34 per hundredweight increase from average processing costs in the May season.

The milk movement patterns indicated by these phase two solutions reinforce the earlier findings that cost-minimizing solutions imply the ability to make seasonal adjustments in the source to destination pairings. As in phase one, specific source to destination pairings change substantially from May to October. Average assembly costs for all milk, even in October, are approximately $0.35 per hundredweight.

Implications

The results indicate that, if total costs of milk assembly and hard product processing are to be minimized over the year, it must be possible to alter milk movement patterns on a seasonal basis. Furthermore, even within a season, individual producers must be indifferent as to the ultimate disposition of their production. This result may provide the best evidence that there are strong economic incentives encouraging the development of the highly coordinated regional milk assembly systems. It is significant that the milk movement patterns to the optimally located milk manufacturing plants identified in this study are substantially different than would likely be the case if the milk assembly function were not coordinated on a regional level. Under uncoordinated atomized systems, producers would be associated, on an annual basis, with specific, localized fluid-use outlets, and the seasonally variable amounts of "excess" fluid milk would accumulate near the bottling plants. If manufacturing facilities were maintained locally, they would likely be small-scale, high-cost operations. Alternatively, aggregating these geographically scattered quantities of "excess" milk in sufficient volume for efficient processing would undoubtedly increase transport costs. Under a regionally coordinated system, as shown in this study, neither situation arises, since combined costs are minimized for the region on a seasonal basis.

Supporting this conclusion is the fact that economies of size in the processing of raw milk into manufactured products tend to be relatively more important than transport costs in determining the optimal number of plants. Total costs continued to decline as plant numbers were reduced to the point where the number of the largest size plants operating at capacity was just adequate to process the available production. While this result tends to reaffirm the conclusions of earlier studies, it is significant that, even with substantially increased costs for energy, the relationship remains intact.

From a public viewpoint, consumer interest groups and others concerned about the effect of increasing industry concentration on retail prices for dairy products should at least be made more cognizant of the potential losses in technical efficiency that may occur if the milk assembly function is atomized. It appears that, for the U.S. dairy industry at least, reducing concentration in milk assembly in an attempt to improve pricing competition, which is difficult to specify at best, would not necessarily put long-run downward pressures on retail prices.[3]

The most dramatically apparent and easily identified inefficiency in the present system from producer through processor is the rather substantial seasonal variation in the amount of raw milk available for manufacturing. While total production in the region only varies by 12.6% over the year, the amount of milk available for manufacturing nearly triples from October to May, reflecting the fact that in this region milk for manufacturing is treated as a residual. There is some question about the ability of producers within the region to match production more nearly with seasonal fluid consumption. Clearly, however, since facilities with the sufficient capacity to handle the high production May season must be provided within the region, this inability is a costly component of the total system.

Both economic and political considerations severely limit the ultimate practicality of an industry organization similar to the one that results from this analysis (Kloth and Blakely). It appears, however, that substantial technical economies remain for an industry organization more concentrated and/or vertically coordinated than the one that exists today.

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[3] If firms in any industry are forced by public policy measures to operate to the left of the minimum point on the long-run average cost curve, while there may be price competition, there can be no assurance that the actual market prices generated will be lower than if a monopolist, operating at or near the minimum point on the long-run average cost curve, set prices so as to maximize profit. Furthermore, while visible price competition may exist in the former case, the often heralded socially desirable consequences of perfect competition will remain unsatisfied.

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Welfare Implications of Alternative Classified Pricing Policies for Milk

Boyd M. Buxton

Questions are being raised about the impact of federal regulations throughout our economic system. Some of these questions have focused on regulations in milk marketing. One particular concern is the impact of pricing milk according to its final use (usually referred to as classified pricing), a basic part of current federal milk marketing orders and many state regulations. In this note, a national aggregate model of the U.S. dairy economy is used to estimate the impact of changing the classified pricing policy on consumer prices of fluid and manufactured dairy products, returns to dairy farmers, and a measure of whether society gains or loses by such a policy change.

Under federal milk marketing orders or by individual state control, processors of fluid milk products are required to pay at least a minimum price for milk actually used in fluid products. In federal marketing orders, under which about 60% of the U.S. milk is marketed, this minimum class I price is calculated by formula utilizing the price paid for milk used in manufacturing in the Minnesota and Wisconsin area. Grade A milk not used for fluid consumption is sold for use in manufacturing at the lower manufacturing milk price. The Grade A milk that is not sold for fluid use, along with all manufacturing grade milk, makes up the available supply for manufacturing purposes. It is the supply of and demand for this milk available for manufacturing that determine the manufacturing milk price and, therefore, the market values of milk in the United States. The dairy price-support program currently places a floor under this manufacturing milk price.

In each federal order the total revenue from class I and manufacturing sales of Grade A milk is pooled and distributed back to Grade A milk producers as a blend price. Dairy farmers producing only manufacturing grade milk (mostly located in the North Central states) receive only the manufacturing milk price. The "all wholesale" milk price computed by the Statistical Reporting Service of the U.S. Department of Agriculture is a weighted price received by all dairy farmers.

The amount that the class I prices paid by processors of fluid milk products exceeds the U.S. average manufacturing milk price varies by region. In 1974, the actual or prevailing class I price (including premiums over minimum federal order prices) exceeded the U.S. manufacturing milk price by about $1.20 in Eau Claire, Wisconsin, while the difference was over $4.00 in Miami, Florida. For the continental United States, the average 1974 U.S. price per hundredweight paid by fluid processors for milk used for fluid ($9.57) exceeded the U.S. manufacturing milk price ($7.13) by $2.44. For this same year, the actual class I price per hundredweight in markets east of the Rocky Mountains exceeded the U.S. manufacturing price by about $1.20 plus 18.8¢ per 100 miles distance from Eau Claire, Wisconsin. In markets west of the Rocky Mountains (including California, which is not under a federal milk marketing order but under state control), class I prices per hundredweight were less than $1.20 plus 18.8¢ per 100 miles from Eau Claire, Wisconsin.

For the same year (1974), the "all wholesale" milk price received by farmers ($8.33) was $1.20 higher than the U.S. manufacturing milk price ($7.13). The difference between the U.S. manufacturing milk price and the "all wholesale" milk price usually has been about $1.00 per hundredweight. In summary, there are three basic prices determining milk supply and utilization in the United States: (*a*) the "class I" price paid by processors of fluid milk; (*b*) the "U.S. manufacturing" price paid by processors of manufactured milk products; and (*c*) the weighted "all wholesale" milk price received by dairy farmers.

Justification for Classified Pricing

Without classified pricing, there is potentially considerable class I price variability in fluid milk markets under current institutional arrangements. This variability would be expected because of the difficulty in balancing fluid demand with Grade A milk supply when fluid milk must be produced only days before it is consumed, must be produced under higher farm sanitary standards than Grade B milk, and is not produced in quantities equal to fluid demand throughout the year. Classified pricing is designed to encourage local production of enough Grade A milk during the low production season to meet the daily fluid requirement plus a reserve so

Boyd M. Buxton is an agricultural economist with the Economic Research Service, U.S. Department of Agriculture, and a professor in the Department of Agricultural and Applied Economics, University of Minnesota.

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that short- or long-supply conditions leading to potentially variable class I prices can be avoided.

Under the class I price differentials of the past, there has developed a trend toward all Grade A milk. In 1975, about 80% of total milk produced in the United States was Grade A, while only about 45% was used as fluid.[1] The amount of excess Grade A milk suggests that the differential between class I and manufacturing milk prices has been too large. Therefore, the average U.S. class I and manufacturing price differential likely would not be sustained by market forces if the minimum federal order class I differentials were reduced in all federal market orders.[2] The implications of a policy to change class I and manufacturing milk price differential are explored by Kessel.

Alternatives Analyzed and Model Used

The changes in milk prices, milk production, fluid consumption, and social welfare are estimated for three alternatives to the 1974 classified pricing policy. These alternatives are: (*a*) reducing the federal order minimum class I and manufacturing milk price differential in Eau Claire, Wisconsin, from \$0.90 to \$0.45 per hundredweight of milk and an equivalent decrease in all other markets (this would be approximately equivalent to lowering the U.S. average prevailing class I and manufacturing milk price differential from \$2.44 to about \$2.00); (*b*) reducing the federal order minimum class I differential in Eau Claire, Wisconsin, from \$0.90 to \$0.25 per hundredweight of milk and an equivalent decrease in all other markets (this would be approximately equivalent to decreasing the U.S. average prevailing class I and manufacturing milk price differential from \$2.44 to \$1.80); and (*c*) increasing the federal order minimum class I differential in Eau Claire, Wisconsin, from \$0.90 to \$1.14 and an equivalent increase in all other markets (this would be approximately equivalent to raising the U.S. average prevailing class I and manufacturing milk price differential from \$2.44 to \$2.68).

These alternatives reflect only changes in the classified pricing policy of milk and do not evaluate the elimination of classified pricing altogether. The reader should not interpret a zero class I differential as an evaluation of eliminating classified pricing because differences between class I and manufacturing prices, as currently measured, likely would still remain without a government classified pricing policy.

The conceptual framework used in this analysis is shown graphically in figure 1. The aggregate U.S. supply curve (labeled *S*) shows the quantity of milk produced in the United States at various all wholesale milk prices. The aggregate demand curve

[1] The 45% figure is milk equivalents on a fat solids basis. An estimated 49% of total milk was required to supply the product pounds of fluid milk and cream consumed in the United States in 1975.

[2] State milk marketing regulations, restrictions on the movement of milk for health standards or other reasons, and/or market power of farmer cooperatives could keep the class I and manufacturing milk price differentials from decreasing.

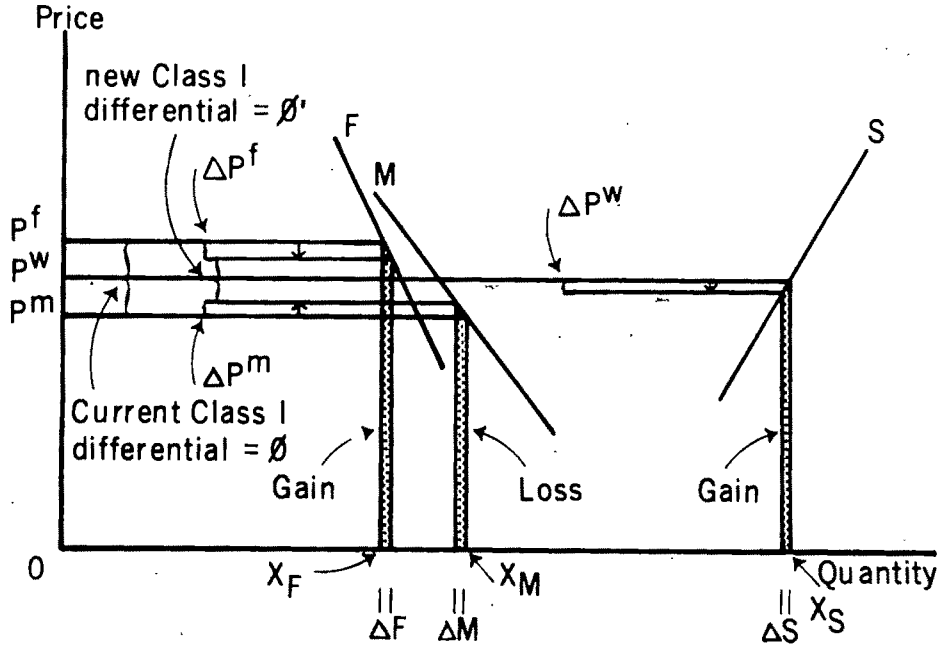


Figure 1. Partial equilibrium model illustrating the net social gain of reducing the U.S. average class I and manufacturing milk price differential

for fluid (labeled F) and manufacturing milk (labeled M) shows the quantity demanded at various fluid and manufacturing milk prices, respectively. The demand for manufacturing milk is derived from the demands for manufactured dairy products. Given the class I and the all wholesale milk price differentials above the U.S. manufacturing milk price, equilibrium is reached when the quantity demanded for fluid and manufacturing equals the total supply. This is represented in figure 1 when the distance OX_F plus OX_M is just equal to OX_S given the price differentials.

The model can be expressed as $F = a + bP^f$, $M = e + fP^m$, and $S = c + dP^w$, where a to f are intercept and slope parameters of the supply and demand equations, and F is the quantity of milk used in fluid products, M is the quantity of milk used in manufactured products, S is the total quantity of milk produced, P^f is the average U.S. class I milk price, P^m is the average U.S. manufacturing milk price, and $P^w = (FP^f + MP^m)/M + F$ = average all wholesale milk price received by farmers.

The policy variable determined under federal milk marketing orders is the size of the average differential between the U.S. class I and manufacturing milk price defined as $\phi = P^f - P^m$. The all wholesale and manufacturing milk price differential is then $\gamma\phi = P^w - P^m$, where γ is the proportion of total milk production used as fluid.

The equilibrium condition is $S - F - M = 0$. Lowering the class I and manufacturing milk price differential (from ϕ to ϕ' in figure 1) is expected to reduce, as shown by the model, the class I prices and the returns to the dairy farmers (lower all wholesale milk price). These price changes lead to an increase in fluid consumption and a decrease in total milk produced. This effectively reduces the quantity of milk available for manufacturing causing the manufacturing milk price to rise. The model, therefore, provides estimates of how the U.S. average fluid, manufacturing, and farm milk prices would change as a result of changing the class I and manufacturing milk price differential.

A Measure of Net Change in Well-Being

The conceptual basis for the measure of whether society is better off or worse off after a change in class I differentials includes an interpretation of what the supply and demand curves represent. (A more detailed discussion of these concepts is presented in Currie, Murphy, and Schmitz. Studies using a similar approach are reported in Wallace, Johnson, and Buxton and Hammond.) The area under the supply curve up to a given quantity produced is a measure of the total production costs in terms of all other goods and services that could have been produced with the resources used to produce that quantity of milk. The area under the fluid and manufacturing demand curves and above the horizontal axis up to the quantities consumed is a measure of the total value of milk consumed (net of processing costs) in terms of all other goods and services.

The gains and losses associated with reducing the class I milk price differentials in all markets are illustrated in figure 1. A new equilibrium, given the lower average U.S. differential, is estimated. The changes in the manufacturing, class I, and all wholesale milk prices and the changes in total milk supply, milk used as fluid, and milk used for manufacturing are then determined.[3] The shaded area under the demand curve for fluid milk represents the total gain to society brought about by lower fluid milk prices and the resulting higher fluid milk consumption. The shaded area under the manufacturing demand curve is a measure of the loss to society brought about by higher manufacturing milk prices and the resulting lower consumption. The shaded area under the supply curve is a measure of the gain, in terms of all other goods and services, to society brought about by using fewer resources to produce the smaller total milk supply.

Assuming the marginal utility of money is the same for all groups involved, a measure of whether society is better or worse off as the result of a decision to reduce the class I and manufacturing milk price differentials is obtained by adding the shaded areas under the fluid demand and supply curves and subtracting the area under the manufacturing demand curve.

Results

Table 1 shows the estimated milk prices, production and consumption, total value of sales, and the measure of net gain (loss) to society of changing the present classified pricing policy to each of the three alternative policies analyzed. Results are obtained using two assumptions about the elasticities of demand and supply: (*a*) the price elasticity of demand for fluid = −0.18, for manufacturing milk = −0.35, and for milk supply = 0.15, and (*b*) the elasticity of demand for fluid = −0.6, for manufacturing milk = −0.85, and for milk supply = 0.5.

Given the first elasticity assumption, the estimated net loss to society of increasing the class I milk price differential from $2.44 to $2.68 is $5.4 million annually (table 1). The dollar value of fluid milk sales would increase an estimated $67 million, while manufacturing milk sales would decline an estimated $32 million. Total revenue to dairy farmers would increase an estimated $35 million annu-

[3] This analysis assumes that the manufacturing milk price is at a market clearing level (above the price support). If the manufacturing milk price was at the price-support level with the government purchasing dairy products, lowering the class I and manufacturing price differential would not be expected to affect the manufacturing milk price. The full decrease in the differentials would be reflected in lower class I prices.

Table 1. Estimated Changes in Prices and Quantities and Annual Social Gain for Three Pricing Alternatives under Two Elasticity Assumptions

	1974 Actual	Alternative U.S. Average Class I and Manufacturing Milk Price Differentials					
	2.44	2.68	2.00	1.80	2.68	2.00	1.80
		Assumption (*a*)			Assumption (*b*)		
		Change from 1974					
U.S. milk prices per cwt. ($)[a]							
Prevailing class I	9.57	0.16	−0.31	−0.45	0.15	−0.29	−0.41
Manufacturing	7.13	−0.08	0.14	0.20	−0.09	0.16	0.21
All milk wholesale	8.33	0.04	−0.08	−0.12	0.03	−0.06	−0.08
Production and consumption (bil. lbs.)							
Consumed as fluid	50.0	−0.16	0.29	0.42	−0.48	0.90	1.29
Used for manufacturing[b]	65.4	0.24	−0.46	−0.65	0.68	−1.28	−1.85
Production	115.4	0.08	−0.17	−0.23	0.20	−0.38	−0.58
Total value of sales (farm level) (mil. $)							
Fluid milk	4,785	67	−128	−186	30	−60	−88
Milk used for manufacturing	4,664	−32	59	84	−9	14	19
Total	9,449	35	−69	−102	21	−46	−69
Net social gain (loss) (mil. $)[c]	0	−5.4	8.6	13.2	−14.8	23.9	33.1

[a] Prices are farm level.
[b] Residual of total milk produced less milk used as fluid.
[c] Assumes that the 1974 class I differential of $2.44 has zero social cost (gain).

Table 2. Average Household Purchases of Selected Dairy Products, April to September 1972, by Substratas

Household Substrata	Fluid Milk	Natural Cheese	Processed Cheese	Nonfat Dry Milk
	Index[a]			
Race				
White	103	104	105	106
Nonwhite	59	48	37	29
Income ($)				
Under 4,000	49	53	41	65
4,000–6,999	76	77	75	97
7,000–9,999	98	85	94	84
10,000–14,999	116	113	121	115
15,000 and over	133	143	136	119
Region				
Northeast	106	97	111	101
South	82	63	80	98
North Central	110	99	112	87
Mountain and Southwest	91	102	95	102
Pacific	101	164	87	128
Age of children				
No children	62	94	63	75
Children less than 6 years old only	110	90	121	74
Children less than 6 years and 13–17 years old only	180	123	188	75
Children 7–12 and 13–17 years old only	188	127	180	227
Average U.S. household	100	100	100	100

Source: Market Research Corporation of America. Data were made available by the Department of Agricultural and Applied Economics, University of Minnesota.
[a] An index of 100 was assigned to the U.S. average household purchases. Indexes then represent deviation of substrata considered from the U.S. average purchases of each dairy product.

ally or, based on 330,000 farms, $106 per farm. Fluid milk prices would rise an estimated 16¢ per hundredweight or about 0.7¢ per half gallon. Manufacturing milk prices would fall 8¢ per hundredweight or about 0.9¢ per pound of butter and 0.4¢ per pound of nonfat dry milk. Cheese prices would fall an estimated 0.8¢ per pound.

The estimated net gain to society of reducing the class I and manufacturing milk price differentials from $2.44 to $1.80 is $13.2 million annually. Fluid milk sales would decrease an estimated $186 million annually, while manufacturing milk sales would increase an estimated $84 million annually. Gross revenue to dairy farmers would decline $102 million or about $309 per farm. Fluid milk prices would fall an estimated 45¢ per hundredweight or about 2¢ per half gallon. Manufacturing milk prices would rise an estimated 20¢ per hundredweight or 2.2¢ per pound of butter and 1.1¢ per pound of nonfat dry milk. Cheese prices would be expected to rise about 2¢ per pound. The estimated impact of reducing class I differentials from $2.44 to $2.00 lies between the results just presented (table 1).

The results are sensitive to how consumers and dairy farmers would respond to price changes. The net social cost of decreasing the class I and manufacturing milk price differential from $2.44 to $1.80 increases from $13.2 million annually with elasticity assumption (*a*) to $33.1 million annually with elasticity assumption (*b*) (table 1).

Implications for Producers and Consumers

Lowering (raising) class I and manufacturing milk price differentials decreases (increases) aggregate returns to dairy farmers. The impact on prices received by farmers probably would not be proportional in all parts of the country. The regional differences are not considered in this paper, as the methodology is designed only to estimate the aggregate impact. Also, the impact on farm income would be much greater on large than on small farms.

Even though the net social gains reported in this study may be accurate, they are quite small relative to the impact on the dairy farmer's gross income and total consumer's expenditures. Hence, classified pricing of milk is much more important from the viewpoint of income transfers between consumers and producers than from the viewpoint of the net gain or loss to society in general.

Data from a 1972 national consumer panel showed that substratas of U.S. households who were heavy (light) consumers of fluid milk relative to the U.S. average tended to be heavy (light) consumers of manufactured dairy products (table 2). This implies that a decrease in fluid milk prices relative to manufactured dairy product prices would not greatly advantage one group relative to any other group within the U.S. population. However, the panel data indicated that relative to all other households the nonwhite and southern households probably would be advantaged somewhat, while households without children or with older children probably would be disadvantaged somewhat.

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Wheat Protein Premiums and Price Differentials

Malcolm D. Bale and Mary E. Ryan

Agricultural commodity research typically investigates demand or supply response to changes in average price levels of a commodity or commodity group. Yet many production and marketing decisions depend upon relative prices of close substitute commodities and often the main demand or supply shifter for a product is the price of its closest substitute. Frequently, the substitute is a different quality, grade, or brand of the same commodity. (Tomek and Robinson provide a useful discussion on price differences, pp. 134–43.) These differences cannot be examined in empirical work where aggregate functions rather than separate, closely related functions are estimated. The research reported in this note investigates the relationships between different qualities of a commodity, adding to the sparse body of empirical work on this topic. A Lancaster "product characteristics" approach is used in differentiating classes of wheat by their protein content characteristic.[1] The specific objective is to generate a simple statistical model for analyzing the effect of changes in available supplies of wheat of various protein content on their relative prices. Prediction rather than complete behavioral understanding is the goal.

Historically, high protein wheats have been relatively scarce, bringing a higher price than lower protein wheats. The price differential is commonly called a "protein premium." The amount of premium for wheats of various protein content varies in response to changing supplies of, and demand for, the protein component of wheat. Demand for high protein wheat is derived from the demand for bread. The demand for low protein wheat is derived from the demand for biscuits, cakes and pastries, and livestock products.[2]

Occasionally, little or no premium is paid for protein. This occurred, for example, during several months in 1972, 1973, and 1974, a period when U.S. exports soared. Earlier research to investigate a possible negative impact of exports on protein premia found that supply factors were associated with much of the variability in the premia (Ryan and Bale, p. 31). Accordingly, this note focuses on the role of supply factors on relative price movements.

Protein is regarded as the differentiating characteristic in wheat. Since the object of this note is to estimate price variations, two price dependent functions of wheats of two different protein contents are specified. The quantity supplied of each commodity is assumed to be predetermined. No short-run supply response is possible because production and carry-in stocks are determined in the previous time period. Only one demand shifter is explicitly specified for each function—the quantity of the major competing wheat.

From the two price dependent functions, one function is formed for estimation, equation (1). The dependent variable is a ratio of the prices of the wheats. The price ratio defines protein premium rather than the more usual definition of price differences (Hyslop). We prefer a price ratio, since it avoids the need to deflate prices. The ratio can, of course, be converted to an absolute difference at any given level of either price:

$$(1) \qquad P_h/P_l = b_0 + b_1 S_h + b_2 S_l + b_3 PP_h + b_4 PP_l + e,$$

where P_h and P_l are the prices of high and low protein wheat, respectively, S_h and S_l are production plus carryover of high and low protein wheat, respectively, PP_h and PP_l are average protein percentages of the high and low protein crops, respectively, and e is an error term. Two variables in equation (1) account for the supply of protein available in each type of wheat. Protein supply varies with the quantity of wheat and its protein content. In both cases, an increase in supply is expected to be associated with a decrease in price of the commodity. Thus, the expected impact on the price ratio is negative for S_h and PP_h and positive for S_l and PP_l. (Opposite signs could occur if the cross-product effects exceed the own-product effects, a less typical case.)

Hard red spring (HRS) and hard red winter (HRW) wheats are selected to represent the high and low protein wheats of the model. Although HRW wheat is considered a "high" protein wheat relative to some other wheat classes, it is generally lower in protein content than HRS. U.S. produc-

Malcolm D. Bale is an assistant professor of economics and agricultural economics, Montana State University, and Mary E. Ryan is an assistant professor of agricultural economics, University of Minnesota.

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[1] Ladd and coworkers have also recently made major theoretical refinements and empirical contributions to the characteristics approach (Ladd and Martin, Ladd and Savannunt). Other work that has examined the demand of wheat by class is Chai, Hyslop, Taplin, and Wang.

[2] Some low protein wheat is used as feed grain. Minor quantities are also used an an "extender" to blend with high protein wheat for bread flour.

Table 1. Regression Analysis Results

P_h/P_l (Mean)	Constant	S_h	S_l	PP_h	PP_l	R^2	S	DW
PS14/PW12	1.565	−0.847	0.158	−0.032	0.016	0.98	0.008	1.89
(1.111)	(8.0)[a]	(16.2)	(5.1)	(4.2)	(2.4)			
PS13/PW12	0.385	−0.504	0.236	0.014	0.038	0.77	0.028	1.07
(1.076)	(0.6)	(2.8)	(2.2)	(0.5)	(1.7)			
PS14/PWO	2.605	−1.010	0.155	−0.085	0.007	0.91	0.026	2.59
(1.154)	(4.1)	(6.8)	(1.5)	(3.4)	(0.3)			
MS15/KW13	2.596	−1.009	0.029	−0.082	0.004	0.91	0.024	2.18
(1.069)	(4.5)	(6.6)	(0.3)	(3.7)	(0.2)			
MS15/KWO	5.418	−1.932	−0.018	−0.175	−0.079	0.92	0.039	1.80
(1.145)	(5.8)	(7.8)	(0.1)	(4.8)	(2.6)			
MS13/KWO	3.264	−1.363	0.667	−0.074	−0.052	0.93	0.028	1.54
(1.089)	(4.9)	(7.7)	(0.6)	(2.9)	(2.4)			
MTS/MTW	3.403	−1.313	0.043	−0.116	−0.010	0.92	0.027	2.82
(1.110)	(5.2)	(7.4)	(0.4)	(4.5)	(0.5)			

[a] t-ratios are given in parentheses, S is the standard error of estimate, and DW is the Durbin-Watson statistic.

Variable definitions: *PS13* and *PS14* are Portland prices of dark northern spring wheat, 13% and 14% protein content, respectively; *PW12* and *PWO* are Portland prices of hard winter wheat, 12% and ordinary protein, respectively; *MS15* and *MS13* are Minneapolis prices of dark northern spring wheat, 15% and 13% protein, respectively; *KW13* and *KWO* are Kansas City prices of hard red winter wheat, 13% and ordinary protein, respectively; *MTS* and *MTW* are Montana farm prices of HRS and HRW wheat, respectively; S_h is production plus carryover of HRS in the United States in billion bushels; S_l is production plus carryover of HRW in the United States in billion bushels; PP_h is average protein percentage of spring wheat produced in North Dakota, excluding durum; and PP_l is average protein percentage of winter wheat produced in Kansas.

tion and carryover data are employed for S_h and S_l. The average protein content of HRS and HRW crops in the two major producing states of each class are used for the protein percentage data. Price ratios analyzed are formed with prices from principal markets for HRS and HRW wheat and with farm prices from Montana where both classes of wheat are grown. Each ratio is formed with a HRS price in the numerator and a HRW price in the denominator.

The model is estimated by ordinary least squares, utilizing annual crop year data from 1965 to 1974. Earlier years were excluded because of the considerable impact of government programs on prices. The results are given in table 1, and figure 1 presents a plot of actual and estimated price ratios of the first equation.

The empirical results are consistent with the hypothesis that good estimates of relative wheat prices can be obtained from simple measures of protein supply. When the quantity of HRS protein increases, the spring to winter wheat price ratio (protein premium) decreases. Over 90% of the variation in each price ratio (except *PS13/PW12*) is associated with variation in the four supply variables. The addition of a linear trend variable to the *PS13/PW12* equation raises its R^2 to 0.98 and increases the significance of S_h, S_l, and PP_l.

The hard red spring wheat variables, S_h and PP_h, have larger and more significant impacts on all price

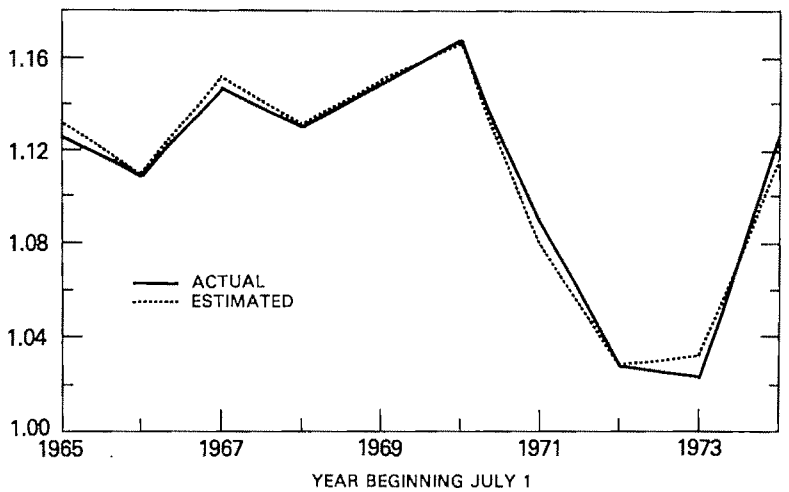


Figure 1. Actual and estimated values of the price ratio of Portland spring wheat 14% protein to winter wheat 12% protein

ratios than the HRW variables, S_t and PP_t. The supply of HRS wheat is the most important explanatory variable in each equation, according to the beta coefficients and t-ratios.

Some interesting differences among markets and pairs of prices are also revealed. Only in Portland, where both HRS and HRW wheats are marketed, do the HRW wheat variables (S_t and PP_t) have hypothesized signs and impacts approaching significance. Significant, but negative, relationships between PP_t and *MS13/KWO* and *MS15/KWO* emerged. Apparently, increased supplies of protein in the HRW crop caused a shift in the HRS demand curve that lowered Minneapolis 13% and 15% HRS prices relatively more than the reduction in the Kansas City price for HRW, ordinary protein wheat.

These results show that four supply variables can be employed in a simple formulation to estimate changes in relative prices of wheats with different protein content. Protein supplies in the HRS crop were more closely associated with changes in the HRS/HRW price ratios than protein supplies in the HRW crop. This note also illustrates that relative price movements between two closely related commodities can be explained by analyzing a common characteristic of the commodities.

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Effects of Retail Pricing and Advertising on Fresh Beef Sales

T. F. Funk, Karl D. Meilke, and H. B. Huff

Beef products constitute a major source of revenue for Canadian supermarkets. It has been estimated that purchases of beef account for approximately 16% of total food expenditures by Canadian consumers (Hassan and Johnson). As a result, the development of effective marketing programs for beef is an important concern of retail food chain managers.

The purpose of this note is to present the results of a research project designed to estimate the retail demand for beef. Because of the management orientation of this research, all of the analysis is performed at the level of the individual supermarket chain and is oriented toward deriving price and advertising elasticities at an aggregate and individual cut level. Since the analysis only covers the period January 1974 through May 1975 and is restricted to the metropolitan Toronto market, extreme care should be taken in extrapolating these results to other time periods and other markets. However, the relatively simple methodology developed demonstrates the feasibility and ease with which individual chain analysts could conduct similar demand studies for their own market situations.

The Model

The basic model used in this research is a retail demand function in which the dependent variable is a measure of weekly beef sales for each chain, while the independent variables are own beef prices, competitors' beef prices, own substitute prices (pork, chicken, veal, and lamb), competitors' substitute prices, own advertising (beef, pork, and other meats), competitors' advertising, and seasonal factors. This formulation does not include three major classes of variables sometimes used in this type of analysis—retail availability, some measure of the "creative aspects" of advertising, and consumer income. In the case of retail availability, prior analysis showed that, during the seventeen-month period covered by the study, the number of retail outlets for each chain was almost constant. As a result, inclusion of this variable would not affect the results. In the case of the creative aspects of advertising, a review of the newspaper advertisements used by the chains reveals that the basic format and design of the advertisements were also more or less the same throughout the period. Thus, the assumption that the "creative variable does not vary" is plausible. Finally, in the case of consumer income, the time period covered by the study was short enough that this variable could not be expected to have any measurable effect.

In the model, local newspaper advertising is the only form of advertising used. The rationale for limiting the analysis to this single form of advertising is twofold. First, newspaper advertising constitutes over 60% of beef advertising expenditures and, hence, is by far the most important media used. Second, newspaper advertising is the only media in which specific products are highlighted (Funk and Meilke). Other media such as television, radio, and in-store displays are used by retail food chains, but the type of advertising used in these media is primarily oriented toward creating a favorable store or corporate image rather than pushing specific products.

To measure the sales response to advertising and price changes in the Toronto market, three classes of data are required: weekly sales levels of beef, weekly prices for beef and other meat products, and weekly newspaper advertising for beef and other meat products. Information on beef sales in Toronto was obtained from Dominion Stores Limited and Food City, two leading supermarket chains serving this market. Both chains were asked to supply data on weekly shipments of beef to all stores in their sales regions and to separate their total beef shipments into carcasses, front quarters, hind quarters, ribs, loins, chucks, hips, and manufacturing boneless beef.[1] Using procedures devel-

Thomas F. Funk is an associate professor and Karl D. Meilke is an assistant professor in the School of Agricultural Economics and Extension Education, University of Guelph; and H. Bruce Huff is an economist in the Economics Branch, Agriculture Canada, Ottawa.

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[1] The fact that the analysis is based on shipments rather than sales is unfortunate, but there is no way to correct for weekly beef carryover by individual stores in the chains. Some of the beef shipped is not sold but held in inventory until the next week, causing some measurement errors in the dependent variables and causing the R^2 values to be lower than they otherwise would be. This point was verified by checking the residuals associated with each equation. In each case where the predicted value was substantially different from the actual value, this follows a week in which an unusually large shipment of beef was made. However, since

oped by the Canadian Cattlemen's Association, the carcasses, quarters, and primals were combined into carcass equivalents for the aggregate analysis and broken out into fourteen retail cuts for the individual cut demand analysis.[2] Although this procedure produces accurate estimates of carcass equivalents, it may introduce some error into the individual cut estimates, since it does not allow for differences in cutting percentages and procedures between chains.

The price data for beef and other meat products used in this research were obtained from the Ambler Pricing Service of Toronto. These data consist of weekly prices for eighteen major beef cuts sold by the five major Toronto food chains over the seventy-two-week period under study.

The advertising data were collected by means of a complete audit of the Toronto Star for the period January 1974 through May 1975.[3] The information collected in this audit consists of date, size of ad, chain, total number of advertised items, number of beef items, number of pork items, number of poultry items, number of veal items, number of lamb items, number of processed meat items, and the advertised prices for individual beef cuts.

Analysis and Results

Aggregate Demand Analysis

The first step in the analysis is to estimate aggregate demand functions for the two chains.[4] The dependent variable is total weekly beef shipments (carcass equivalents) to the stores, while the independent variables are: P is the own beef price, P_c is the competitors' beef price, RPP is the relative price of pork, RPL is the relative price of lamb, BA is the number of own beef ads, PA is the number of own pork ads, OA is the number of own other meat ads, BA_c is the number of competitors' beef ads, PA_c is the number of competitors' pork ads, and OA_c is the number of competitors' other meat ads.[5]

Table 1. Results of Aggregate Demand Analysis

Independent Variables	Dominion	Food City
Own price elasticities		
P	−1.52[a]	−5.97[a]
Cross-chain price elasticities		
P_c		3.77[a]
Cross-product price elasticities		
RPP	2.25	1.74
RPL		0.99[a]
Own advertising elasticities		
BA	0.12[a]	0.15[a]
PA	−0.13[a]	−0.04
OA	0.19[a]	−0.03
Cross-chain advertising elasticities		
BA_c	−0.02	0.07
PA_c	−0.14	−0.01
OA_c	0.12	−0.63[a]
R^2	0.56	0.60
D.W.	2.00	2.58

[a] Denotes elasticities computed from regression coefficients with t-ratios larger than 1.67.

The results of this analysis, in the form of elasticities, are shown in table 1. These elasticities can be interpreted as the percentage change in weekly beef sales associated with a 1% change in any of the independent variables, holding all other variables constant. Those elasticities shown with an "a" are computed from regression coefficients with t-ratios larger than 1.67.

At Food City, a relatively small Toronto chain, a decrease in beef prices holding competitors' prices constant resulted in a substantial increase in beef sales. Multicollinearity between Dominion's average beef price and its competitors' average price is too strong to allow for measurement of the separate effects of these two variables. The estimated own price elasticity of −1.52 in table 1 measures the sales increase generated by a change in the general beef price level rather than a change in price of beef at Dominion relative to its competitors. For this

this only occurs a few times during the seventy-two-week period of analysis, it is not felt that this seriously influences the results.

[2] To construct average carcass values, the prices of eighteen beef cuts are used. In the individual cut demand analysis, only fourteen cuts are analyzed, omitting stewing beef, flank steak, brisket, and shank center. These cuts, accounting for 9.4% of the carcass, are omitted because data on shipments of the brisket and flank primals were not collected. Stewing beef is left out because its source could not be identified.

[3] Only one Toronto newspaper is included in the advertising audit, since it is the only paper that regularly features food ads. Two other Toronto newspapers occasionally carry food ads, but the size of these ads and the frequency with which they appear are inconsequential compared with the ads in the Toronto Star.

[4] All of the demand functions are estimated using ordinary least squares. A single-equation approach is appropriate, since supply is perfectly elastic for a small local market within the North American beef industry. Likewise, there is no simultaneity on the demand side as long as retailers use standard mark-up techniques to determine their prices. The residuals in the aggregate supermarket demand functions may be correlated, but the lack of sufficient data to model the entire Toronto market makes the use of a seemingly unrelated regression procedure less attractive (Kmenta, pp. 517–28).

[5] The independent variables are calculated as follows. Own beef price is calculated as a weighted average of the eighteen retail cuts for which data were available. Competitors' beef price is calculated as a weighted average price of the eighteen retail cuts for the four other competitive retail firms. Relative price of pork is calculated by dividing the average price of pork loin chops and picnic roast for each chain by the average price of the four other competitors. Relative price of lamb is calculated by dividing the average price of leg of lamb, shank half, for each chain by the average price of the four other competitors. Own and competitors' ads are included in the model as the number of mentions, since no attempt is made in the newspaper audit to measure the amount of space devoted to each item.

reason, the less elastic direct price elasticity at Dominion relative to Food City is not surprising. For both chains, an increase in beef advertising is associated with an increase in beef sales; however, this effect is relatively small.

The sales response of beef to pork advertising for Dominion is negative, implying that as Dominion increases pork advertising beef sales decline. The sales response of beef to other meat advertising, on the other hand, is positive for Dominion. The direction of this relationship is somewhat surprising but apparently reflects the fact that other meat advertising at Dominion stimulates sales of all meats, including beef, instead of stimulating the sales of other meats at the expense of beef. Beef and pork advertising of competitors is not related to beef sales at the two chains under consideration in this analysis. However, other meat advertising of competitors has a negative and fairly substantial effect on beef sales at Food City.

Individual Cut Demand Analysis

An attempt is made to estimate separate demand functions for individual beef cuts. The basic model used in this part of the analysis is similar to that used in the aggregate analysis, with the exception that the prices and advertisements are not averaged over all cuts but rather inserted as separate variables in the equations.[6]

The large number of individual beef cuts considered, and the interaction possibilities among these cuts, leads to a situation where an extremely large number of independent variables are eligible for inclusion in any of the demand equations. Because of the inherent problems involved in estimating and interpreting equations of such size, a procedure was developed to reduce the size of each equation while preserving as much information as possible. This procedure consists of two steps. In the first step, an equation consisting of the own price and own advertising variables is estimated, while allowing for the possibility of any of the other variables entering the equation in a stepwise manner. The information obtained in this step then is used to select variables for inclusion in the equations in the next step, provided they meet two inclusion criteria. These criteria are that the variables have to have the correct (hypothesized) sign and that they have to have a t-value greater than 0.85. The second step in this procedure consists of reestimating each equation using a stepwise option to pull in all of the variables meeting the above criteria.[7]

The elasticities calculated from the regression equations for Dominion and Food City and the definition of symbols used are shown in tables 2 and 3.[8] The results in these tables are separated into different types of elasticities for each of the fourteen beef cuts considered at each chain.

Eight of the fourteen own price elasticities for Dominion are significant and negative as expected, compared with only two of the fourteen for Food City. All of the significant price elasticities are greater than one except for short rib roasts at Dominion. In general, there seems to be some relationship between the "quality" of the cut and its price elasticity, with higher quality cuts being more price elastic.[9]

The cross-cut price elasticities show the percentage change in sales of each cut given a 1% change in the price of some other cut. The results in tables 2 and 3 show that there are relatively few relationships between the sales of one cut and the price of another, but those relationships that are pesent are fairly strong, as evidenced by the large values found.

The cross-product price elasticities show the percentage change in sales of each beef cut given a 1% change in relative prices of pork, veal, and lamb. Again, the results show relatively few such cross-product relationships, but those that are present are fairly large. Also, it appears that pork is a better substitute for steaks than for roasts, given the number of significant cross-product elasticities between the categories of products.

The own meat advertising elasticities show the percentage change in sales of each beef cut given a 1% change in the number of beef, pork, and other meat ads run by the chain. The signs of these elasticities are hypothesized to be positive for beef ads, negative for pork ads, and either for other meat ads. With the single exception of the relationship between the sales of short rib roasts and pork ads at Dominion, all of the signs are in the hypothesized direction, and all are found to be less than one.

The final section of tables 2 and 3 shows the effect of specials on the sales of individual beef cuts. Because of the discrete nature of this variable (a cut is either specialed or it is not), it is included in each demand equation as a dummy variable. As a result, it is not meaningful to calculate an elasticity for this variable. Instead, positive or negative signs are shown for each statistically significant variable, indicating the direction of the effect of the special.

The first row under the heading effect of specials (SP) shows the effect of specialing a cut on the sales of that cut. As expected, all the significant variables

[6] A seemingly unrelated regression procedure was tried in estimating the individual cut demands for each supermarket, but the results were similar to the ordinary least squares estimates.

[7] Given the search procedure followed in selecting the variables included in each equation, the standard statistical tests should be interpreted very carefully; i.e., the stated level of significance is distorted (Freund, Freund and Debertin).

[8] The beef price variables in the individual cut demand analysis are expressed as actual prices for each individual chain. Prices relative to those in other chains were used in preliminary analysis and found to give results inferior, in terms of goodness of fit and expected signs, to those using actual prices.

[9] This result is confirmed by MacAulay when he found the direct short-run price elasticities for non-fed beef to be substantially lower than for fed beef in western Canada, eastern Canada, and the United States.

Table 2. Results of Individual Cut Demand Analysis for Dominion

Independent Variables	Beef Cuts[b]													
	BRR	*CRR*	*ERR*	*PSRS*	*PRR*	*RR*	*SRR*	*TRR*	*SR*	*PS*	*RS*	*SS*	*WS*	*MBCR*
Own price elasticities														
P	−4.19[a]	−1.67	1.20	−1.09	−1.05	−6.52[a]	−0.58[a]	−7.46[a]	−1.45[a]	−1.26[a]	0.02	−1.33[a]	−1.27[a]	−0.28
Cross-cut price elasticities														
P_{ERR}	5.41[a]					7.02[a]		6.33[a]						
P_{PSRS}								2.48						
Cross-product price elasticities														
RPP		4.67								5.14[a]		5.98[a]	4.76	
RPV						1.15								
RPL							1.20[a]							
Own meat advertising elasticities														
BA				0.19[a]			0.09[a]							
PA		−0.32[a]		−0.20[a]			0.16[a]		−0.26[a]	−0.23[a]		−0.29[a]	−0.29[a]	−0.13[a]
OA		0.60[a]		0.25					0.30	0.33[a]		0.37[a]	0.34[a]	0.17[a]
Effect on specials														
SP		+			+					+	+			
SP_{BRR}		−	+					+						
SP_{CRR}								−	+					
SP_{PRR}											+			
SP_{TRR}				−					−					
SP_{WS}					−					−				
R^2	0.44	0.75	0.35	0.35	0.45	0.40	0.49	0.49	0.69	0.37	0.37	0.34	0.32	0.25
D.W.	2.49	2.58	2.12	2.10	2.25	2.37	2.24	2.24	2.51	1.83	2.18	1.98	2.06	1.53

[a] Denotes elasticities computed from regression coefficients with *t*-ratios larger than 1.67.
[b] *P* is individual cut prices, *RPP* is relative price of pork, *RPV* is relative price of veal, *RPL* is relative price of lamb, *BA* is the number of beef ads, *PA* is the number of pork ads, *OA* is the number of other meat ads, *SP* is advertised specials (1 if cut is specialed; 0 otherwise), *BRR* is bottom round roast, *CRR* is cross rib roast, *ERR* is eye of round roast, *PSRS* is point sirloin roast and steak, *PRR* is prime rib roast, *RR* is rump roast, *SRR* is short rib roast, *TRR* is top round roast, *SR* is shoulder roast, *PS* is Porterhouse steak, *FS* is flank steak, *RS* is rib steak, *SS* is sirloin steak, *WS* is wing steak, *BRSK* is brisket, and *MBCR* is minced beef, chuck, round.

Table 3. Results of Individual Cut Demand Analysis for Food City

	Beef Cuts[b]													
	BRR	*CRR*	*ERR*	*PSRS*	*PRR*	*RR*	*SRR*	*TRR*	*SR*	*PS*	*RS*	*SS*	*WS*	*MBCR*
Own price elasticities														
P	0.16	−1.16	0.13	−1.32	0.69	−2.13	−0.16	−0.01	−0.75	−6.73[a]	0.66	−0.52	−3.59[a]	−0.61
Cross-cut price elasticities														
P_{ERR}										2.75[a]				
P_{PSRS}										3.49[a]			6.33[a]	
P_{FS}										7.84[a]				
Cross-product price elasticities														
RPP		6.65		9.25	4.97		4.52		5.16		5.85[a]		−5.23[a]	
RPV										1.72[a]				
Own meat advertising elasticities														
BA	0.33[a]	0.12	0.35[a]					0.33[a]						
PA					−0.20		−0.28[a]							
OA		−0.95[a]												
Effect of specials														
SP	+	+			+	+	+	+	+	+	+	+	+	+
SP_{BRR}			+					+						
SP_{CRR}			−											
SP_{PSRS}												+		
SP_{PRR}											+			
SP_{TRR}	+									−				
SP_{SR}	−						−	−						−
SP_{RS}		−			+		+							
SP_{BRSK}		−							−					
R^2	0.50	0.72	0.44	0.15	0.67	0.39	0.65	0.50	0.86	0.86	0.69	0.63	0.86	0.25
D.W.	2.38	2.31	2.33	2.41	1.91	2.34	1.82	2.39	2.23	2.03	1.84	2.29	2.15	2.00

[a] Denotes elasticities computed from regression coefficients with *t*-ratios larger than 1.67.
[b] See note b, table 2.

here for both chains are positive. It is particularly interesting to observe the differences between the two chains wth respect to this variable. In the case of Dominion, only four cuts are found to respond significantly to specials, whereas in the case of Food City, twelve cuts show a significant response.

The other entries under the heading effect of specials show the effects of specialing one cut on the sales of another. Here, negative signs would be expected for cuts that are substitutes and positive signs for cuts that are complements. Only a few of these cross-cut advertising relationships are found, and most of them are negative.

Conclusions

Several tentative conclusions are possible. For individual chains, aggregate beef sales are price elastic. This implies there is some incentive for chains to lower average prices, since such a strategy results in an increase in total revenue, assuming everything else remains the same. In the aggregate, cross-product prices appeared to play a small role over the study period.

Own advertising elasticities both in the aggregate and for individual cuts tend to be positive but substantially less elastic than own price elasticities. This does not, however, imply that reducing prices is preferable to increasing advertising if the objective of the firm is profit maximization. Such a determination obviously depends on the costs of the two approaches.

Pork advertising tends to have a negative effect on beef sales, while other meat advertising has a positive effect. In general, the advertising of competitors was not found to be very important.

Substantial differences exist between chains in terms of the magnitude of price and advertising effects. While these are probably due to differences in store location, store types, etc., sufficient data were not available to determine the exact reasons for these differences.

Perhaps the most important contribution of this research is to indicate how easily chain store managers could conduct similar demand studies to help in selecting a basic marketing strategy. The type of data used in this study are readily available to industry analysts and, in fact, could be improved upon by accounting for in-store meat carryover and meat-cutting differences between stores. The demand analysis could be used to determine where the major sales effects of price and advertising changes should be focused and therefore how to increase sales and profits.

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The Effect of Income Tax Progressivity on Valuations of Income Streams by Individuals

Roy D. Adams

The effect of taxes upon investment patterns in agriculture is an important policy consideration that has received attention in past issues of this *Journal*. However, some authors have inadequately adjusted income-stream valuation formulas for the effect of the individual income tax and have consequently reached incorrect conclusions regarding both the present value of future income and the effect of income tax progressivity on the relative valuations of individuals in different tax brackets. Rodewald (1969, 1971) and Devino consider the effect of taxes and financing upon investment decisions, but their incomplete treatments of income taxes produce a valuation formula that results in incorrect investment decisions. A more recent paper by Harris and Nehring considers the impact of farm size on the bidding potential for agricultural land. Like Rodewald and Devino, they adjust the income stream for taxes but do not incorporate individual income tax rates in the discount rate used for computing present values. Consequently, they conclude that the progressivity of individual income tax rates puts high tax bracket individuals at a competitive disadvantage in bidding for the perpetual income stream produced by agricultural land.

The purpose of this note is to clarify the effect of income tax rates upon the present value of income streams subject to normal income taxes and to describe how income tax effects may be incorporated into general valuation formulas. The next section discusses the relation between present value analysis and bid-price models and notes some practical limitations of the latter. Subsequent sections describe how risk can be correctly incorporated in present value calculations, how normal income taxes affect present values, and how the availability of tax-exempt municipal bond interest affects the present value of taxable income streams and limits the optimum level of taxable investment income.

Roy D. Adams is an assistant professor of economics at Iowa State University.

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Investment Decision Models

Two different investment decision models are contained in the papers mentioned above. The simpler of the two is that used by Rodewald. In it one computes the present value of the after-tax income stream provided by an asset and purchases it only if that present value is greater than or equal to the cost of the asset.

The bid-price model used by Harris and Nehring provides a considerably broader framework for investment decisions. They also compute a present value (using a risk-free discount rate), but the investment decision is not made solely on the basis of that present value. An investor's bid price also depends on the risk associated with the considered income stream, the investor's preferences regarding risk, the riskiness of the investor's existing portfolio, and the covariance between the return on presently held assets and the return provided by the considered asset. Bid prices equal present values only if the investor is risk neutral or if acquisition of the asset does not change the riskiness of his portfolio holdings. Thus, bid prices are conceptually more general and complete than are decision rules based solely on present value. Whether the bid-price model provides a useful improvement depends critically on the availability and reliability of the additional information required to compute bid prices. That information includes detailed characteristics of investors' utility functions, in addition to estimates of the risks and covariance mentioned above.

Many investors lack at least some of the information needed for bid-price calculations and consequently focus on present values in making investment decisions. The following section presents a method for incorporating risk into present value calculations without recourse to the information about utility functions required for bid-price models. Since Harris and Nehring's bid-price model includes a present value computation, the points made here regarding taxes and present values apply to both decision models. Any tax effects upon present values also apply to bid prices, although the converse is not always true. Since bid-price models incorporate utility functions, taxes may have wealth effects on bid prices that do not appear in present value formulas.

Present Value of Uncertain Income Streams

An important characteristic of many income streams is that they are highly variable over time. This feature is incorporated into bid-price models, but Rodewald does not explicitly consider it in his present value approach to investment decisions. Hirshleifer (1970) discusses two possible methods of accounting for the riskiness of income streams in computing present values. One method (*a*) is to reduce the distribution of possible returns in each future period to a certainty-equivalent value, then discount that series of terms with a riskless discount rate to obtain the "present certainty-equivalent value." The certainty-equivalent value, like bid prices, depends on the investor's utility function. The alternate method (*b*) is to compute the mathematical expectation of the return in each future period, then discount this series with the discount rate appropriate to the "risk class" of the investment.[1] Hirshleifer notes that, although both approaches "lead in principle to the same correct result, the information gaps that are the source of the difficulty require in practice the employment of method (*b*) above" (p. 262).

In its simplest form, the recommended procedure requires only two pieces of information. One is an estimate of the expected value of the net income produced by the asset in each future year π_t; the other is the prevailing rate of return r^o on other assets in the same risk class. The principle underlying estimation of π_t is that it is returns to invested capital. Therefore, one subtracts from each year's expected receipts all costs of inputs other than capital. Property taxes are subtracted because other assets not subject to the property tax are available.[2] Debt interest should not be subtracted because it is part of the return to capital invested in the asset.

The choice of the appropriate risky discount rate is guided by the principle that it should indicate the rate of return available on assets containing the same degree of risk as the considered investment. Since the variance of net income from farmland depends on such factors as the chosen cropping pattern and the amount of insurance purchased, the appropriate risky discount rate may vary among investors planning different uses of the land. The appropriate rate may be difficult to estimate precisely, but as Hirschleifer (1961, p. 118) has noted, the risky discount rate "is at least more of an observable magnitude than the abstract riskless rate of interest." Since the general level of prices is unstable, riskfree investments would exist only if some assets were both free of default risk and were effectively indexed against purchasing power risk. Currently, the riskless interest rate cannot be observed, but a wide range of risky rates are visible.

[1] The concept of risk-equivalent classes of assets is discussed by Modigliani and Miller in their 1958 and 1963 papers. Income streams in a risk class differ only by a factor of porportionality.

[2] If property taxes are expected to grow over time, this expectation should be incorporated.

Income Taxes and Present Values

The above procedure recommended by Hirshleifer abstracts completely from income taxes; the expected income stream and the discount rate he discusses are both in gross-of-tax terms. This section shows that taxes may be safely ignored only when valuing an income stream that is both perpetual and is subject to only normal income taxes. If the income stream is finite in time or if special income tax features such as accelerated depreciation, capital gains, tax credits, etc., apply to it, the individual's tax rate does affect present values and must be applied to both the income stream and the discount rate.

As Modigliani and Miller (1963) note in their analysis of the effect of corporate income taxes upon costs of capital and valuation formulas, there are two equally good methods for valuing perpetual income streams subject only to normal taxes. One can either discount gross-of-tax returns with the gross-of-tax cost of capital or one can discount net-of-tax income with the net-of-tax cost of capital. Their footnote 16 (1963, pp. 441–42) states:

> "Although the before-tax and the net-of-tax approaches to the cost of capital provide equally good criteria for investment decisions when assets are assumed to generate perpetual (i.e., nondepreciating) streams, such is not the case when assets are assumed to have finite lives. . . . In the latter event, the correct method for determining the desirability of an investment would be, in principle, to discount the net-of-tax stream at the net-of-tax cost of capital. Only under this net-of-tax approach would it be possible to take into account the deductibility of depreciation. . . ."

The expressions for the after-tax costs of capital developed by Modigliani and Miller (1958, 1963) for corporations are not applicable to individual proprietors because individuals are not subject to the corporate income tax. The appropriate discount rate for individual (unincorporated) investors to use in computing present values is the rate of return available on other assets in the same risk class; this is the opportunity cost of alternate uses of invested funds, regardless of whether the source of those funds is equity, debt, or any combination of the two.[3] Therefore, the gross-of-tax cost of capital

[3] This approach is consistent with Modigliani and Miller's findings. Their 1958 paper shows that, in the absence of corporate income taxes, the cost of capital to a firm is independent of its debt-equity mix and equal to the rate of return to unlevered equity invested in its risk class. Their 1963 paper shows that the corporate income tax does create an advantage to corporate debt finance and that the correct discount rate for corporate investment decisions does depend on leverage. However, the tax effect is the only permanent advantage to corporate debt, and this advantage does not apply to individual unincorporated investors. It can be shown that the debt-equity mix of individual investors strongly affects the expected value and variance of returns to invested equity. However, the debt-equity mix is irrelevant to present values because the effects of leverage apply to all investments and should not be

invested by an individual is simply r^o, the prevailing rate-of-return in the asset's risk class, and the net-of-tax cost of capital is $r^o(1 - t)$, where t is the investor's marginal income tax rate. The net-of-tax expression recognizes that foregone returns would be subject to taxation (unless it is municipal interest discussed below).[4]

The simple formula for the present value of a perpetuity illustrates Modigliani and Miller's point about the equivalence of the gross-of-tax and net-of-tax approaches. The present value V of the net-of-tax perpetual income stream $\pi(1 - t)$, discounted with the net-of-tax cost of capital $r^o(1 - t)$, is identical to the present value of the gross-of-tax perpetual stream π, discounted at the gross-of-tax cost of capital r^o:

$$V = \frac{\pi(1 - t)}{r^o(1 - t)} = \frac{\pi}{r^o}. \tag{1}$$

This also demonstrates that the present value of a perpetual stream does not depend on the tax bracket of the individual.[5]

The problem with Harris and Nehring, Rodewald, and Devino's present value formulas is that Harris and Nehring explicitly, and Rodewald and Devino apparently, use a gross-of-tax interest rate to discount net-of-tax income streams. Harris and Nehring note that their present value formula (equation (6), p. 162) implies that individual valuations decrease as the marginal income tax rate rises and high income persons *ceteris paribus* bid less for farmland than do persons in lower tax brackets. Since neither Devino nor Rodewald mentioned any adjustment of the discount rate for income tax rates, they presumably would also use a gross-of-tax rate in discounting. If so, Harris and Nehring's conclusion is also implied by Rodewald's and Devino's analyses.

Although income taxes may be safely ignored in valuing perpetuities subject only to normal income taxes, this is not true in general. If the income stream is subject to only normal taxes, and if it terminates after n periods, its present value is

$$V^* = \sum_{i=1}^{n} \frac{\pi(1 - t)}{[1 + r^o(1 - t)]^i} = \frac{\pi}{r^o}\left[1 - \frac{1}{[1 + r^o(1 - t)]^n}\right]. \tag{2}$$

Since

$$\frac{\partial V^*}{\partial t} < 0, \tag{3}$$

the present value of the income stream is less to high tax bracket individuals than to those with lower marginal tax rates. Samuelson derives this relation and also shows that the effect may be offset by the effect of the deductions for depreciation, which commonly apply to assets with finite lives. As Samuelson shows, the net effect of the tax rate vanishes only when tax deductible depreciation exactly equals true economic depreciation.

If the considered income stream qualifies for any special tax considerations, such as accelerated depreciation deductions or the investment tax credit, then (as Modigliani and Miller argue) the net-of-tax approach is required. In this case, one needs to adjust the expected income stream for the tax factors considered by Rodewald and by Devino, but two corrections to Rodewald's method are required. One, recognized by Devino, is that those finance charges that represent interest on debt should not be subtracted because the discount rate accounts for the required return on all capital invested. Second, the discount rate must be adjusted for the individual's marginal tax rate to obtain the net-of-tax opportunity cost of capital he invests. The present value of finite income streams that qualify for special tax treatment generally does depend on the individual's tax rate. Normally taxed perpetuities (such as indefinitely held farmland) are a special case in which the tax rate has no effect on present value.

The Effect of Municipal Bonds

Although the progressivity of the income tax per se does not reduce high income persons' valuations of normally taxed, perpetual income streams, the availability of tax-exempt interest from municipal bonds does put an upper limit on the optimum level of taxable investment income and does thereby deter some high tax bracket individuals from acquiring taxable income streams.

Figure 1 illustrates the optimal investment strategy for high income individuals, where Y_1 is the individual's wage and salary income minus exemptions and deductions, Y_o is equal to Y_1 minus taxes on Y_1, Y_m is the level of taxable income above which municipals provide the greatest after-tax return, and $Y_2 = Y_m - Y_1$ is the optimal level of taxable investment income. Maximum after-tax income from invested equity is obtained by investing $\$Y_2/r^o$ in assets paying a taxable return of r^o and investing the remainder of equity in municipals paying rate r^m. Line 1 shows gross-of-tax income from this strategy, and line 2 shows net-of-tax income. The initial segments of line 2 have slopes equal to $r^o(1 - t)$, and the kinks corresponds to movements between tax brackets. Line 3 shows the inferior

attributed to any particular investment. If a considered asset is to provide as large a return to levered equity as do other assets in its risk class, it must provide $\$r^o$ of gross-of-tax returns to each (equity and debt) dollar invested.

[4] The net-of-tax expression is less simple if part of the return is growth. Since allowing for income growth over time complicates the exposition of this section without charging the results, I assume henceforth that the income stream considered is not expected to grow over time.

[5] The omission of the special treatment of capital gains in this formula is justified by the assumption that the investor expects to retain the asset (in his family) indefinitely.

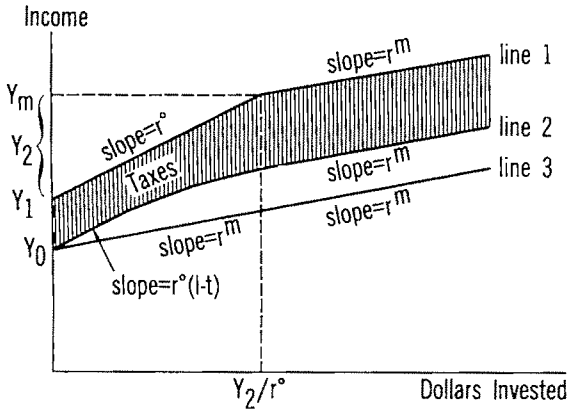


Figure 1. Gross and net-of-tax income with taxable and tax-exempt investment returns

net-of-tax return that results from a portfolio comprised entirely of municipal bonds. The optimum level of taxable investment income to acquire before moving into municipals is determined by Y_1, the individual's taxable wage and salary income; Y_m is determined by the structure of interest rates and tax rates.

Municipal bond holders' valuations of the taxable income stream π depend on the value of π relative to the investor's optimum level of taxable investment income, Y_2. If $\pi \leq Y_2$, then the appropriate net-of-tax discount rate for valuing the net-of-tax returns $\pi(1-t)$ is $r^o(1-t)$, despite the fact that the investor holds some municipals. Since the optimum portfolio contains $Y_2 \geq \pi$ of taxable investment income, the asset producing π is substituted for previously held assets producing taxable income at the rate r^o. Therefore, municipal bond holders whose optimum taxable investment income level is as large as π value π as highly as do lower tax bracket individuals.

However, those investors for whom $\pi > Y_2$ attach a lower present value to π than do lower bracket individuals. Consider first those individuals for whom $Y_2 = 0$ because their wage and salary income alone puts them in the tax bracket where the highest after-tax return on invested equity is obtained from municipal bonds paying rate r^m. This rate is the after-tax opportunity cost of capital for them and is the appropriate discount rate for valuing after-tax returns. Since in this tax bracket $r^m > r^o(1-t)$, using r^m as the discount rate causes their valuation of π to be less than that of lower tax bracket individuals. To match their valuations, the after-tax opportunity cost of capital has to be the lower rate $r^o(1-t)$.

If the municipal bond holder's optimal level of taxable investment income is positive but less than π, his valuation of π lies between the two cases just considered. The excess of $\pi(1-t)$ over $Y_2(1-t)$ is discounted at rate r^m, and these investors' valuations also fall below those of persons in lower tax brackets.

Municipal bond holders' valuations of taxable income streams are less than other individuals' valuations if acquisition of the taxable income stream raises their taxable investment income above the optimum. Whether this is the case depends largely on the municipal bond holder's level of taxable wage and salary income. If this is high, then optimal taxable investment income is low, and large taxable income streams are valued less by them than by others.

The existence of an upper bound on the optimum level of taxable income an investor wants to receive (before investing in municipals) was previously recognized by Dean and Carter. In their analysis of the effect of income taxes upon the optimum size of unincorporated firms operating in an industry where economies of scale exist, they recognize that, because of progressive tax rates and the availability of tax-exempt interest, individuals find that beyond a limit the after-tax return from expanded farm size is less than the municipal rate.

However, Dean and Carter (p. 762, note 12) also argue that this limit may be circumvented by the use of debt. In their scenario, a high bracket individual limits his equity investment in the farm operation and expands with debt while investing his residual equity in municipals. The tax deductions from debt interest keep down the level of taxable income from the enterprise, while scale expands with invested debt capital. Carman implicitly accepted the validity of Dean and Carter's analysis when he examined the effects of the Tax Reform Act of 1969 on optimum farm size. However, Dean and Carter's analysis ignores a provision of the income tax law that prohibits the scenario they describe.

Section 265(2) of the Internal Revenue Code of 1954 stipulates, "No deduction shall be allowed for interest on indebtedness incurred or continued to purchase or carry obligations . . . the interest on which is wholly exempt from the taxes imposed by this subtitle" (*U.S. Code*).[6] The Revenue Procedures (72-18 and 74-8) issued by the IRS to set guidelines concerning 265(2) and the court cases interpreting this provision indicate that it does not automatically disallow all interest deductions by municipal bond holders (Internal Revenue Cumulative Bull. 1972-1, pp. 740–43, 1974-1, pp. 419–20). Among other allowances, the courts have permitted interest deductions on loans taken for nonrecurrent business needs. In the case of *Wisconsin Cheeseman, Inc. v. United States*, the courts permitted the deduction of interest on a loan, the proceeds of which were used to pay for the construction of a new plant, although Cheeseman held municipals (*U.S. Tax Cases* 1968, para. 9145, pp. 86, 153–56). Similarly, in the case of *Ball v. Commissioner*, Ball,

[6] If this prohibition did not exist, individuals in high tax brackets could earn arbitrage profits by borrowing money, deducting the interest from taxable income, and investing the loan proceeds in tax-exempt municipal bonds.

who held tax-exempt bonds throughout the relevant years, was permitted interest deductions on a variety of loans, including two that were used to acquire ranches (*Rep. of the U.S. Tax Court*, pp. 1200–1209).

However, the courts have also ruled that interest deductions on such loans become disallowed if the loans are continued beyond some reasonable retirement period. In the case of *Illinois Terminal Railroad Co. v. United States*, the court disallowed the deduction of interest on a loan originally incurred in connection with the acquisition of a bridge because the court's opinion was that the railroad's dominant purpose in continuing the loan was to maintain its holdings of tax-exempt bonds (U.S. Tax Cases 1967, para. 9374, pp. 83, 968–73). I infer from these and related cases that the municipal bond holder who uses debt in purchasing land is permitted to deduct the interest only if the debt is retired within some "reasonable" interval.[7] Therefore, investors cannot indefinitely use debt to circumvent the upper bound on optimum taxable income identified in figure 1. Consequently, some municipal bond holders will find taxable income streams unattractive because of this limit.

Conclusions

One of the principal conclusions of this analysis is that the progressivity of the income tax per se does not affect different investors' valuations of normally taxed perpetual income streams. Since farmland does not qualify for special tax factors unless it is resold, investors planning indefinite holding of land are not differentially affected by progressive income tax considerations. However, the availability of tax-exempt municipal interest limits the optimum level of taxable investment income, and section 265(2) of the IRS Code prohibits circumventing this limit with the use of debt. Therefore, municipal bond holders are deterred from acquiring taxable income streams if the acquisition moves them above the optimum level of taxable income. A previous study by Dean and Carter ignores section 265(2) and consequently overestimates optimum farm size.

Although my results, like those of Harris and Nehring, imply that high income investors may value farmland less highly than lower income individuals, the source and extent of the valuation disadvantage differ. Harris and Nehring's attribution of the valuation disadvantage to the progressivity of the income tax implies that the effect operates throughout all levels of taxable income. My conclusion is that the progressivity of the income tax deters only some high income municipal bond holders from acquiring farmland. Further, this effect is attributable to the existence of municipal interest rather than to the progressive income tax itself.

Although most investors may safely ignore income tax rates in the significant special case of farmland valuation, this analysis indicates that asset valuation should generally be conducted in net-of-tax terms. To correctly value nonperpetual income streams and assets qualifying for special tax consideration, it is necessary to adjust both the income stream and the discount rate for the effect of individual income tax rates.

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[7] Neither the IRS nor the courts have specified how quickly debt must be retired to avoid invoking 265(2), but the Illinois Terminal Railroad Co. case demonstrates that indefinite continuance of debt is not permitted.

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Long-Run Productivity of Insecticides

Gerald A. Carlson

Public concern over the hazards to wildlife and human health associated with insecticides has prompted research on the private costs and returns from the use of these chemicals. Headley uses 1963 state data to estimate a $4 return for each dollar of pesticide materials of all types (fungicides, herbicides, insecticides, etc.) used on U.S. farms. He indicates that this result helped explain the rapid increase in sales volume of pesticides. But during the 1960s producers were giving additional attention to pest control as more insect species became resistant to more chemical types. Many policy questions on the limitation of use and registration of insecticides require more detailed knowledge of the demand for specific compounds. Regulatory officials are concerned about the substitutability of other chemical and nonchemical pest controls (Davis et al.). Yet, no statistical estimates of insecticide demand are presently available.

The importance of insecticide resistance in affecting demand for specific compounds and the long-run productivity of insecticides are investigated in this paper. Individual farm data from several cotton production regions and aggregate insecticide use data are used to test hypotheses of falling productivity of insecticides and substitutability between chemical types.

Long-Run Insect Management

Insect management decisions involve the use of insect density, specie, crop tolerance, and weather information to regulate pest suppression resources to maximize profits. Several authors have used a kill function to refer to the efficacy or productivity of pesticides (Hueth and Regev). Genetic composition of the pest population and weather can influence the percentage kill obtained by a given insecticide dosage. Langham and Mara use data from weather-controlled experiments to illustrate how percentage kill is determined by number of pest generations exposed to a given insecticide dosage. Economists and entomologists have also hypothesized that rate of insecticide resistance development is determined by insecticide dosage or amount of selective pressure (Adkisson, Hueth and Regev).

Hueth and Regev have presented a model to show that in the presence of increasing insecticide resistance both current and future efficacy of an insecticide must be considered in determining optimal use rates of a single insecticide through time. Their model is helpful in understanding that dosages per acre might be increased to maintain current yields, or they might be decreased to preserve survival of susceptible insects and, thereby, lower future control costs. To make the theoretical model of Hueth and Regev operational, one must have observations on pest numbers and insecticide resistance. If pest numbers are available and all other factors affecting crop yield are accounted for, changes in the marginal productivity of insecticides will indicate a change in the level of insecticide resistance. One of the main objectives of the next section is to estimate expenditure functions to determine if insecticide productivity has decreased with time in various cotton production areas.[1]

A second resource allocation problem is the selection of the mix of insecticides given relative prices and productivities of specific compounds in a given period. If physical effectiveness of specific insecticides is falling through time due to resistance development, what responses have growers made? Insecticide type might be substituted at a slightly higher price per unit of material to maintain or increase percentage kill. Similarly, resistance might lead to increased use of land and other inputs per unit of final product. These adjustments can be examined by deriving and estimating a demand equation for individual insecticide products.[2]

Insecticide Productivity in U.S. Cotton Production

Assume that the cotton production process can be described by expenditures for insecticides (X_1), fer-

Gerald A. Carlson is an associate professor in the Department of Economics and Business, North Carolina State University, on leave at the University of Washington.

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[1] Admittedly, this stops short of calculating optimal insecticide productivity and insecticide use rates. Such an analysis depends upon unknown rates of chemical discovery, rates of decline in resistance when insecticide use is reduced, and the factors mentioned in the text.

[2] A dynamic model such as one similar to Hueth and Regev would also have interest rates, product price, and the rate of change in interest rates and insecticide prices in the factor demand equations. In this static approximation, changes in insecticide prices and interest rates have been omitted. Product price variables were deleted because of lack of statistical significance.

tilizer and lime (X_2), other materials (X_3), land (X_4), labor (X_5), power and equipment (X_6), custom work (X_7), and pest abundance (P). The output resulting from these inputs is given by value of cotton produced (Y). If these inputs (X_i) are combined in multiplicative fashion, then an estimation model with unknown parameters (β_0, β_i, β_8) and error term u can be specified as:

$$(1) \quad Y = \beta_0 \Pi X_i^{\beta_i} P^{\beta_8} u \text{ for } i = 1, 2, \ldots, 7.$$

It is assumed that the function is linear-homogeneous and input prices are constant for all cotton farms of a given size in a region.[3]

Equation (1) has pest abundance as a biological input. The productivity of insecticide materials is likely to be closed linked to pest numbers. In this case, pest abundance is measured as an index of uncontrolled pests as indicated by weeks of greater than 5% bollworm-damaged squares. Where infestation measures are not available, insecticide expenditure (X_1) alone is used in the model.

The sample data used to test for the existence of changes in insecticide productivity were collected by personal interviews of cotton growers across the U.S. cotton production regions for 1964, 1966, and 1969 (USDA 1966, 1969, 1972). Table 1 gives ordinary least-square estimates of expenditure elasticities (β_i) for southeastern and Rio Grande Valley cotton farms utilizing equation (1). A high proportion of total variation in the value of cotton produced is accounted for by these seven groups of expenditures. The finding of interest is that the expenditure elasticity for insecticides declines during both the 1964–66 and 1966–69 intervals for both regions.

The model was also estimated using sample data from other cotton production regions for each of the three years. The marginal physical products (MPP's) for the insecticide variable (X_1) for four of the regions are given in table 2. The Delta-P entries were derived from estimates of equation (1) with inclusion of a measure of pest density (P). The effect of accounting for pest density is to increase the MPP of insecticides about 20% (estimate of all three years combined) and increase its t-values (compare standard errors of IV and V).

The marginal physical products of insecticides are an estimate of the productivity of insecticides for mean dosages if all other factors affecting yield are held constant. Since mean expenditure shares for insecticides are relatively constant for the 1964–69 period for each region (USDA 1966, 1969, 1972), one cannot attribute changes in the MPP's to shifts along the kill function.[4] The changes in the insecticide MPP's are due to shifts in the kill function itself. The distinctive feature of the MPP estimates is the decreases with time for the Southeast and the Delta regions, with small declines in the Rio Grande Valley. There seems to be no evidence of falling productivity in California.

The data support the hypothesis of falling physical productivity of insecticides. The annual rates of decline are higher for later periods (1966–69) for the Southeast and the Delta (table 2). One might question the statistical significance of the shift from 1966 to 1969 because of the high standard error on the insecticide variable in 1969 for all regions except California. However, the 95% confidence interval of marginal physical products for 1964 does not include the 1969 value for the Southeast and the Delta region (adjusted for infestation—Delta-P).

[3] This permits expenditures on insecticides to be a proxy for insecticide quantity. As one reviewer noted, this also requires that the mix of insecticides across farms must be the same, since different compounds have different prices per pound. Examination of individual farm data indicates that this assumption is not too extreme for the homogeneous cotton areas chosen by USDA and used for this study (USDA 1966, 1969, 1972).

[4] The expenditure shares for the 1964, 1966, and 1969 periods are: Southeast—6.9, 8.7, and 8.6; Rio Grande—8.9, 11.0, and 5.0; California—1.4, 1.2, and 1.9; and Delta—3.0, 3.4, and 5.1 (USDA 1966, 1969, 1972).

Table 1. Cotton Production Expenditure Functions

	Southeast[a]			Rio Grande Valley		
	1964	1966	1969	1964	1966	1969
Constant (X_0)	1.84	1.80	2.05	1.45	2.49	3.08
Insecticides (X_1)	0.031	0.027	0.007	0.062	0.041	0.007
Fertilizer and lime (X_2)	0.384	0.368	0.570	0.020	0.022	0.011
Other materials (X_3)	0.107	0.133	0.097	0.230	0.231	0.202
Land (X_4)	0.094	0.101	0.086	0.259	0.249	0.450
Labor (X_5)	0.285	0.185	0.228	0.258	0.090	0.149
Power (X_6)	0.120	0.197	0.004	0.201	0.310	0.058
Custom (X_7)	0.022	0.034	0.037	0.076	0.060	0.037
R^2	0.901	0.863	0.859	0.938	0.958	0.961
N	863	535	399	369	239	177

Note: t-values for all but four coefficients are greater than 2.0. t-values for the others are 0.39 and 0.64 for variable X_1 in 1969 for the Southeast and Rio Grande Valley, respectively, 1.4 for X_2 in the Rio Grande Valley in 1969, and 0.9 for X_6 in 1969 in the Southeast.

[a] Includes production in North Carolina, South Carolina, Georgia, and part of Alabama. See Economic Research Service reports for area delineations, sampling procedures, and other characteristics of the USDA cotton surveys (USDA 1966, 1969, 1972).

Table 2. Marginal Physical Products of Cotton Insecticides

Region	1964	1966	1969
I Southeast	1.85	1.07	0.24
	(0.50)	(0.58)	(0.63)
II Rio Grande Valley	2.88	2.47	1.54
	(0.93)	(1.14)	(1.40)
III California[a]	48.30	16.67	26.47
	(13.45)	(11.66)	(7.06)
IV Delta[b]	20.97	13.20	0.91
	(10.13)	(3.95)	(5.35)
V Delta-P[c]	31.79	16.17	2.55
	(12.18)	(4.04)	(5.67)

Note: MPP's are computed as $(\beta_1 \cdot \bar{Y}/\bar{X}_1)$ (regional cotton insecticide price per pound/regional cotton lint price for each year) (Eichers et al. 1970; USDA 1966, 1969, 1972); standard errors are given in parentheses.

[a] Includes some production in southwestern Arizona. See ERS reports for delineation of subregions (USDA 1966, 1969, 1972).

[b] Includes production in twenty-five counties and adjacent counties in Arkansas, Mississippi, Tennessee, and Missouri for which infestation records were available (Lincoln and Boyer).

[c] Same cotton farms as equation (IV), except a measure of bollworm infestation has been included in the estimation of equation (1).

Demand for Selected Insecticides

There appear to be reductions in the technical efficiency of cotton insecticides during the 1960s as shown above. To determine how insecticide users respond to resistance, one must examine their purchases of various insecticides. The demand model briefly outlined above can be estimated if insecticide prices, quantities, and a measure of insecticide resistance are available.

Resistance measures applicable to U.S. insecticide use are difficult to obtain because of lack of comparability between pest species, crops, and areas. Dosages required to kill 50% of a pest population (LD-50) are a common measure for laboratory and small field-plot studies of degree of genetic change (resistance) in a population (Adkisson, Brown 1971). For more aggregate analysis, a measure is needed that emphasizes the geographical and insecticide use intensity dimensions of resistance. One of the most extensive tabulations of insecticide resistance is given by Brown (1971). He has compiled dates of first reportings of resistance, by major pest by state. An index of organochlorine insecticide resistance for various years was computed from his list of references. Table 3 shows the insect species, host crops, states, and dates of resistance occurrence for major insect species.[5] The pounds of organochlorine insecticides to which resistant pests apply was estimated by using host crop acreage times the average pounds of organochlorines applied per acre as given in the first U.S. Department of Agriculture pesticide survey (Eichers et al. 1968). Host crop acreages are assumed to be the state acreage in the specified year unless the pest is only found in part of the state

[5] Only agricultural pests are included in the index computation. Most of the public health pest resistance to organochlorines occurred prior to 1951 in the United States (Brown 1971). However, this omission may account for the reduced magnitude of the coefficient on the resistant variable when the years prior to 1953 are included in the DDT model, equation (D), table 4.

Table 3. Organochlorine Insecticide Resistance by Major Insect Species

Year	Insect Species[a]	Major Host Crop	States[a]	Estimated Pounds O.C. (A_i)[b]
1951	Coddling moth	apples	Ohio	0.5
1952	Coddling moth	apples	New York	2.1
1953	Coddling moth	apples	Washington	1.2
1955	Boll weevil	cotton	Ark., La.	10.5
1956	Boll weevil	cotton	Tex., Miss., S.C.	30.3
1959	Boll weevil	cotton	Ala., Okla., N.C.	8.7
	Coddling moth	apples	6 minor apple states	0.4
1961	Tomato hornworm	tobacco	N.C., S.C.	5.2
1962	Corn earworm	cotton	La., Ark., Tex.	33.5
	N. corn rootworm	corn	S.D., Ohio, Ill.	0.3
1963	Tobacco budworm	cotton	Tex., Miss.	3.2
	W. corn rootworm	corn	Nebr., Kansas, S.D.	0.2
1964	W. corn rootworm	corn	Iowa, Mo., Minn.	4.2
	N. corn rootworm	corn	Iowa, Minn., Wisc.	5.0
1965	Tobacco budworm	cotton	Louisiana	1.5
	Corn earworm	cotton	Miss., Ala.	18.3
1966	Cabbage looper	cotton, soybeans	Calif., La., N.C., S.C.	6.2
	S. corn rootworm	corn	Vir., N.C.	3.2

[a] From a check of first reported resistant insects as reported in the references in Brown 1971.

[b] Estimated host acreage times pounds of organochlorine (O.C.) insecticides per acre for the particular specie (Brown 1971, Eichers et al. 1968).

(such as boll weevil in Texas). Because of time delays between first reports of resistance and widespread geographical distribution of resistant populations, a two-year lag is selected.[6] The resistance index values (e_t) are cumulated for year t as

$$e_t = e_{t-1} + A_{t-2}, \tag{2}$$

where A_t is the estimated pounds of organochlorine insecticides used for control of the resistant species as given in table 3.[7]

The resistance index (table 3) is dominated by the cotton pests because of the large proportion of insecticides used for these species. The index is only an approximation for the large number of insect species that have various degrees of resistance to the organochlorine insecticides in any year. However coarse it may be, it is the most complete index compiled to date. It may be refined enough to help explain wide swings in pesticide use over the past two decades.

Annual U.S. insecticide use data for the period 1945 to 1970 (1969 for DDT) are used for analysis. This excludes the effects of registration removals, since most were after 1970. Price and quantity data for several classes of organochlorine and organophosphorous insecticides were compiled from tariff commission sales data (USDA 1953–71, U.S. Tariff Commission) and export information (USDA 1953–71, U.S. Dep. Commerce). The estimation model is

$$Q_t = c_0 + c_1R_{1t} + c_2R_{2t} + c_3e_t + c_4C_t + E_t, \tag{3}$$

where Q_t is the quantity (in pounds of actual material) of a given insecticide purchased in year t, R_1 is the insecticide price deflated by an index of all agricultural input prices, R_2 is the substitute insecticide price, e_t is the resistance index, C_t is the agricultural product price index, and E_t is the error term. The model was estimated in linear-log form. The agricultural product price variable was not statistically significant and was deleted from the model.[8] A lagged dependent variable (R_3) is added to account for the assumed effects of delayed adjustments to price changes.[9]

Table 4 presents parameter estimates for equation (3) for several of the largest selling groups of insecticides. Insecticide price (R_1) has the expected negative effect on insecticide purchases for all three groups of compounds examined. Since the model is estimated in log-log form, the coefficients on R_1 and R_2 are direct and cross price elasticities, respectively. The sales of these compounds are quite re-

[6] This was based on the detailed studies of the geographical and chemical spectrum of resistance that have been conducted for tobacco budworm on cotton and the western corn rootworm (Adkisson, Brown 1970).

[7] Because of the lag, resistance index values are needed for the 1953–68 period. Data for the 1967–68 period are incomplete. It is assumed that the rate of increase in e_t is the same as for the 1962–66 period. This linear extrapolation to obtain a small part of the index (12%) is not expected to alter the results very much. The starting point ($t = 0$) is assumed equal to 1.0.

[8] Since insecticide expenditures constitute a small share of total farm production costs (usually less than 5%) and the sales include nonagricultural and agricultural use of insecticides, it is not surprising to find no discernible product price effect. This model change does not change the estimated coefficients for the other variables.

[9] The justification of the delayed adjustment to achieve desired levels of use is the same as Griliches gives for fertilizer use. The lagged dependent variable did not prove to be statistically significant and was deleted for insecticides other than DDT.

Table 4. Demand Equations for Selected Insecticides

Chemicals	Constant	Own Deflated Price[a] (R_1)	Substitute Price[b] (R_2)	Resistance[c] (e_t)	Lagged Dependent[d] (R_3)	R^2
(A)	−2.578	−1.461	0.830	1.51	—	0.941
		(0.796)	(0.683)	(0.158)		
(B)	−4.218	−1.552	0.886	1.85	—	0.960
		(0.780)	(0.670)	(0.155)		
(C)	−1.244	−1.06	0.261	0.958	—	0.968
		(0.273)	(0.43)	(0.167)		
(D)	−2.261	−0.667	—	−0.340	0.759	0.585
		(0.397)		(0.179)	(0.153)	
(E)	−4.522	−1.091	−0.118	−0.747	0.797	0.815
		(0.625)	(0.526)	(0.319)	(0.200)	

Note: Dependent variables in the equations are: (A) domestic and foreign quantity of cyclic organophosphate insecticides (1953–70); (B) same as (A) except dependent variable is divided by domestic cotton acreage planted; (C) total quantity of parathion and methyl parathion (1953–70); (D) domestic quantity of DDT (1945–69); and (E) domestic quantity of DDT (1953–69). Standard errors are in parentheses.

[a] Annual weighted average prices deflated by index of all farm input prices.

[b] In the cases of equations (A), (B), and (C), this is organochlorine weighted average price; for DDT this is average price of cyclic organophosphates.

[c] Cumulative pounds of organochlorines with resistant insects as given in table 3 in 10 million pounds, lagged two years.

[d] All Durbin-Watson statistics are nonsignificant or inconclusive. Durbin's two-sided test for first-order serial correlation in the presence of a lagged dependent variable is nonsignificant with X^2 equal to 3.06 and 34.3 for equations (D) and (E), respectively.

sponsive to price. All direct price elasticities except for the one in equation (D) are greater than |1|. This indicates that there are many substitute pest controls in the long run. Costs of restricting the use of particular insecticides may not be as high as implied by studies such as Davis et al., which allow limited factor and product substitution.[10]

Organochlorine resistance (e_t) explains a high proportion of the variation in annual insecticide purchases for each of the chemicals examined. Resistance to organochlorine increases the demand for organophosphates—the major replacement insecticide. Resistance tends to increase the use of substitute chemicals and decrease the use of the resistant chemical. Resistance is not as important in equation (D) because it includes data from the earlier period (1945–51) for which agricultural resistance was reported to be at the zero level. Resistance has a larger effect on organophosphate sales per acre of cotton than on total sales (compare the coefficient of e_t for equations (A) and (B)).

With one exception other variables have the anticipated effects. Substitute insecticide prices (R_2) (organophosphate prices in DDT equations, organochlorine prices in organophosphate equations) have the expected positive sign in the organophosphorous equations (A), (B), and (C). In the case of DDT (equation (E)), which has many petroleum substitutes for health-related pests, substitute price shows no effect. The predictability of the demand for DDT is enhanced by inclusion of a lagged dependent variable, R_3. The inclusion of delayed adjustments to relative prices does not weaken the association between resistance and insecticide demand. Thus, the overall effect of resistance to specific compounds is to encourage chemical substitution and reduce dosages per acre.

Insecticide Productivity Policy

The recognition of the dynamic nature of pests has led to a description of the pest control process with pesticide productivity or presence of resistance as an important dimension. Analysis of individual farm data from several cotton production regions indicates that the marginal productivity of insecticides in some areas has fallen substantially between 1964 and 1969. If insecticides are similar to other productive inputs (noninferior), one can expect lower use as effectiveness falls. In addition, if the rate of use influences the rate of decline in effectiveness, then insecticide users will decrease use to delay resistance development. The time-series model results are direct evidence that farmers and others are shifting between insecticide types and adjusting use to avoid the development of resistance for the major insecticides.[11]

The decline in insecticide productivity seems to have been encouraged by several economic and institutional forces. The common-property nature of a genetic pool of nonresistant pests suggests that private producers acting in their own interests may underinvest in preserving this resource. Collective efforts for entire regions, in the form of restraints on insecticide use, may be in order if their net benefits exceed those of individual action.

Another public activity that probably influences resistance development is removal of federal insecticide registrations. Reducing the number of chemical types used on an insect specie increases selective pressure from the compounds remaining. It is ironic that deliberations on the social benefits and costs of restricting use of specific compounds have given little weight to effects on future productivity of substitute compounds.

This paper has not attempted to evaluate the costs of activities to delay resistance development. Mixing insecticides, rotating insecticides, avoiding early season insecticide treatments by the use of field scouts, or spatially or temporarily altering cropping patterns are possibilities that come to mind. Likewise, no attempt has been made to answer the question of the effect of resistance development on rates of discovery of new chemical controls. Investigation of the costs of these and other attempts to preserve our ability to control insects should be undertaken by biological scientists and economists.

During the 1950s and 1960s as resistance intensified for one chemical, replacements were available at small price increases. There was little private incentive to preserve productivity. However, the costs of discovering compounds that are both environmentally safe and profitable has increased the breakeven life of a chemical greatly. Few new insecticides are forthcoming. However, the sales potential of an effective new compound is rising. Policy makers should be encouraged to consider the effects of resistance on the relative productivities of restricted and unrestricted insecticides in their deliberations on use regulations and investments.

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[10] The USDA implicitly assumes a demand elasticity that is about one-third the above estimates (Davis et al.).

[11] The development of resistance to organophosphates and the rise in importance of nonchemical controls that is currently taking place has not been evaluated here.

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Factors Affecting the Supply of Off-Farm Labor Among Small Farmers in Taiwan

Donald W. Larson and Hung Yu Hu

Many low-income countries have achieved rapid economic growth in recent years, but the benefits of this growth often have been concentrated in the hands of few individuals. Poverty among small farmers is still one of the most serious problems confronting these countries.

Two main strategies have been used to deal with the small farmer problem. The first strategy has stressed development of new technology and production services to increase the productivity and profitability of the resources used in agriculture. This approach often benefits large farmers more than small farmers because the limited land holdings and other resources of the latter prevent efficient use of much technology; in addition, they are often denied access to production services. A second strategy is migration from rural to urban areas. High rates of rural-urban migration in developing and developed countries have only transferred the human resource problem from one area to another. The migrants who tend to be poor, unskilled, and underemployed increase the burden on overcrowded urban areas that already suffer from high unemployment rates and large numbers of "marginalized" families. For these reasons, some new approaches to this problem should be considered, although they conflict slightly with traditional concepts of agricultural economics.

Off-farm work, a third strategy to deal with the small farmer problem, offers much potential for alleviating low farm incomes, yet it has been generally overlooked in the development literature. Few studies of off-farm work have been completed in either high- or low-income countries. Furthermore, few countries or aid agencies have adopted policies designed to let members of rural households remain on farms while encouraging them to do part-time off-farm work to increase labor productivity and household income. The principal objective of this study is to explore the main microeconomic factors that affect the supply of off-farm work among rural Taiwanese households.

Traditionally, agricultural economists have considered off-farm income as a "by-product" of farms; their attention generally has focused on the problems of how to increase farm income and how to encourage full-time farming. Following recent economic development in many countries, however, off-farm income has increased at a much more rapid rate than farm income, and its changes have deeply affected rural household incomes, farmers' savings, and consumption. In Taiwan, for example, rural households unable to increase their income through increasing farm size have substantially boosted their purchasing power through off-farm work. Farmers' welfare has often been assumed to be directly related to the size of farm business. But a recent study by Larson has shown that size of farm and farm income are no longer precise indicators of farmers' welfare in the United States.

Off-farm income in many countries has become an increasingly important part of rural household income. As can be noted in table 1, off-farm incomes in the United States and Japan are relatively high percentages of rural household incomes and have increased at fairly rapid rates in both countries.[1] Off-farm income in Taiwan was a relatively unimportant source of household income until 1960; since then it has increased at a very rapid rate, so that it now represents nearly 40% of rural household income. In Korea, off-farm income makes up a significant part of household income, but the percentage has not changed noticeably since 1960. These data indicate that the share of household income earned off the farm has increased rapidly in the 1960 to 1974 period and that it will likely continue to increase in the foreseeable future. Because little is known about off-farm income, research is needed to identify the causes for this rapid growth and the implications for agricultural development. Strategies and policies to affect this process can then be developed.

This study focuses on the rural household in an effort to understand the economic factors that affect off-farm work and attempts to measure the effects of these factors from farm level cross-section data. The main data used in this study were

Donald W. Larson is an associate professor and Hung Yu Hu is a former graduate assistant in the Department of Agricultural Economics and Rural Sociology, Ohio State University.

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[1] Misawa shows that off-farm employment in Japan became important in the 1940s and has increased rapidly since the 1950s.

Table 1. Off-Farm Income as a Percentage of Rural Household Income in the United States, Japan, Taiwan, and Korea, 1960–74

Year	United States	Japan	Taiwan	Korea
		%		
1960	39.2	50.0	13.4	NA
1961	40.1	56.4	13.5	NA
1962	42.4	52.8	15.2	20.4
1963	44.4	55.0	13.8	17.9
1964	49.2	56.5	17.7	17.5
1965	46.8	56.3	19.4	20.8
1966	46.8	56.4	18.3	22.1
1967	51.2	55.1	18.7	22.2
1968	53.3	57.8	19.9	23.5
1969	52.0	62.2	28.9	23.3
1970	52.9	68.1	27.7	24.1
1971	53.5	73.6	28.1	18.1
1972	51.3	72.7	39.4	17.7
1973	39.8	72.4	41.3	18.8
1974	47.4	NA	37.3	19.7

Sources: USDA; Japan, Ministry of Agriculture and Forestry; Taiwan, Provincial Government of, Department of Agriculture and Forestry; Korea, Republic of, Ministry of Agriculture and Fisheries.
Note: Off-farm income includes wage and salary incomes received from off-farm employment, net income from nonfarm self-employment, and other incomes.

obtained from the 1973 records of 329 farm families distributed in the eight agricultural regions of Taiwan. The data were collected by the Taiwan Provincial Department of Agriculture and Forestry as part of a farm record-keeping project. The data collected by this project are very reliable because households voluntarily recorded their economic activities daily, and supervisors checked this information regularly.

Taiwan was selected for this study because the agricultural sector and the general economy have experienced rapid development. The gross national product has increased at an 8% to 10% real annual rate since the early 1950s, and agricultural production has increased in excess of 5% annually during the same period (Hu). In addition, the government since 1953 has successively launched six four-year development plans to achieve the simultaneous growth of agriculture and industry. Rapid growth of the nonfarm sector, whose industrial output has increased at more than a 12% annual rate, has led to a significant transformation of the economic structure in Taiwan. Agricultural employment as a percentage of total employment has dropped from 61% in 1952 to 37% in 1973, and agricultural net domestic production as a percentage of total net domestic production dropped from 38% to 16% in the same period. The benefits of this rapid growth have also been relatively equitably distributed, thereby creating new opportunities for a large proportion of the population (Oshima).

The Economic Model

A major concern of the study is to determine how Taiwanese farmers distribute their labor between on and off-farm work. Polzin and MacDonald's study for the United States presents a theory useful in explaining the equilibrium between on and off-farm work. Assuming that the individual farmer is a price taker in the nonfarm labor market, the optimal division of time is that point where the marginal revenue product of farm work equals the net wage rate of the nonfarm sector. An increase in the off-farm wage rate causes the farmer to increase the supply of off-farm work. Similarly, an increase in net farm income causes the farmer to reduce his off-farm labor supply.

Commuting costs of the farm family are also expected to affect the off-farm labor supply. Commuting cost, an increasing function of distance in most cases, lowers the net off-farm wage rate and consequently the amount of off-farm work. Since data on commuting costs were unavailable, the ratio of agricultural population to total population in the township was used to represent these costs (Polzin and MacDonald).

Educational levels and size of family are expected to be directly related to the off-farm labor supply. Higher educational levels increase labor skills and, therefore, the opportunity for off-farm work (Hanson and Spitze). Households with many adults have a bigger pool of labor available for both on and off-farm work. The rural household labor pool increases if the wives and older family members assume the farm work when other family members obtain off-farm employment (Mizoguchi).

Changes in the consumption pattern of rural households as they adjust upward their desired standard of living may also affect the off-farm labor supply. As consumption changes, rural households are induced to earn more income in order to achieve a higher standard of living. Although Adams, Canh, and Chin argue that the consumption bundle has changed dramatically in Taiwan during the study period, the lack of data precludes use of this variable in the model proposed here.

Lastly, farming type may affect the off-farm labor supply, since some types of farming, such as vegetable and tobacco, are more labor intensive than others such as rice.

In summary, equation (1) presents the formal specification of the basic Taiwanese model as follows:

$$(1) \quad L_n = f(W_n/I,\ C,\ S,\ A,\ M_h,\ N_f,\ D_l,\ U),$$

where $\partial L_n/\partial(W_n/I) > 0$, $\partial L_n/\partial C < 0$, $\partial L_n/\partial S > 0$, $\partial L_n/\partial A > 0$, $\partial L_n/\partial M_h > 0$, $\partial L_n/\partial N_f < 0$, and $\partial L_n/\partial D_l \gtrless 0$. The off-farm labor supply L_n, measured in man-days, is a function of the ratio of daily wages of off-farm work to net farm income (W_n/I), the percentage of agricultural population to total population in the township (C), average schooling years of

adults (S), number of adults in family (A), stock of farm machinery per hectare in New Taiwan dollars (M_h), farm land in hectares (N_f), farming types (D_i)—a dummy variable used to represent the five farming types of rice (D_0), vegetable and tobacco (D_1), fruit (D_2), other crops (D_3), and livestock (D_4)—and the error term (U).

Linear and double logarithmic functional forms were estimated in the analysis; however, only the results from the linear model are reported here because it provides a better statistical goodness of fit. (See Hu for further details concerning the different functional forms that were tested.)

The Results

The average off-farm labor per rural household was 308 man-days in 1973. The coefficient on W_n/I, the ratio of daily nonfarm wages to net farm income, is significant at the 1% level and has the expected sign; that is, an increase in nonfarm wages or a decrease in net farm income is associated with more off-farm work (table 2). However, the supply elasticity of off-farm labor with respect to W_n/I at the mean of the observations is small, which implies that a change of 10% in the ratio of nonfarm wages to net farm income causes a change of about 0.5% in off-farm labor supply.[2]

The coefficient of C, the percentage of agricultural population to total population in the township, is not significant but does have the expected sign. This suggests that commuting cost has little influence on the labor supply. A possible reason for this is that the commuting distance to off-farm employment is relatively small in Taiwan because the country is geographically small and because both agricultural and industrial centers are located in a narrow seashore plain and upland. There does not seem to have been enough variance to measure in Taiwan on this issue. Commuting cost might be an important factor in other countries that are less confined geographically.

The coefficient of S, average schooling years of adults in a family, is significant at the 1% level and has the expected sign. In addition, the elasticity of labor supply with respect to this variable is elastic, suggesting that an increase of 10% in average schooling years for farmers is associated with a more than 10% increase in the supply of off-farm labor.[3] As shown in table 2, an increase of one year in the average schooling years of adults in a family is associated with forty-seven more off-farm labor days annually.

The number of adults in a family is significant at the 1% level and has the expected sign. It shows that an increase of one adult in a family provides about fifty-nine additional man-days of off-farm labor per year.

The positive sign and statistically significant coefficient of M_h, stock of farm machinery per hectare, means that the supply of off-farm labor is increased if more farm machinery is used on farms. The elasticity of labor supply with respect to M_h is about 0.18.

The variable farmland (N_f) has a negative coefficient, significant at the 1% level, which means that a 10% increase in farm size is associated with a 0.27% decrease in the supply of off-farm labor.[4]

Among the four farming types, the coefficients on vegetable and tobacco farms (D_1) and fruit farms (D_2) are significant at the 5% level and have the expected sign. The negative sign means that vegetable and tobacco and fruit farms provide less off-farm labor than rice farms. As these farm types increase in number, the supply of off-farm labor decreases.

[2] Sample farms were divided into "comparatively large" and "comparatively small" farms to estimate the off-farm labor supply function for the two groups. The dummy variables method was used to test the equality of each pair of coefficients between the two regressions. The off-farm labor supply elasticity with respect to W_n/I was larger (0.129) for small farmers than for large farmers (0.027).

Table 2. Regression Results and Elasticities of the Supply of Off-Farm Labor Among Taiwanese Farmers (Total Sample)

Independent Variable	Regression Coefficient	t-Value	Elasticity at Mean Value
Constant	−241.708	4.010	—
W_n/I	5,016.754	3.117	0.052
C	−0.507	0.832	0.104
S	47.229	9.761	1.063
A	59.007	11.618	0.908
M_h	0.005	6.542	0.178
N_f	−55.108	7.336	−0.275
D_1	−51.496	1.713	−0.014
D_2	−54.360	2.074	−0.020
D_3	−8.696	0.356	−0.004
D_4	2.608	0.114	0.013
$\bar{R}^2$	0.639		
F-Ratio	59.04		
D.F.	10,318		

Conclusions and Policy Implications

The findings of this study suggest that the rural household level variables that significantly affect the off-farm labor supply are (*a*) the ratio of daily nonfarm wages to net farm income (W_n/I), (*b*) the

[3] This labor supply elasticity, estimated from cross-sectional data at one point in time, fails to include members of the household who may have been educated in rural areas and then moved to the city. A time-series analysis might result in an even higher elasticity for education.

[4] An additional variable, land use intensity, was included in a second equation not reported here. This variable had a coefficient that was significant and with a negative sign, which suggests that as land use intensity increases, off-farm labor decreases.

educational level of the members of the rural household (S), (c) the number of adults in the household (A), (d) the degree of mechanization on farms (M_h), and (e) the farm size (N_f).

The results indicate that the off-farm labor supply is inelastic with respect to W_n/I (0.05). Therefore, the extent to which rural households seek off-farm work depends upon nonfarm wage and agricultural price relationships. Off-farm wage rates are sufficiently high relative to farm incomes in Taiwan so that rural households have the incentive to seek off-farm work. In other words, the gap between urban incomes and rural incomes makes off-farm work attractive. A government policy of low food prices (common in many less developed countries) in combination with high urban wage rates due to rapid economic growth or minimum wage policy induces rural households to seek off-farm work or to migrate. Taiwanese policy seems to have achieved the former without triggering massive increases in rural-urban migration.

The off-farm labor supply is elastic with respect to the average educational level of rural household members. A 1% increase in the educational level of the rural household results in a more than 1% increase in the quantity of off-farm work. Off-farm work is, therefore, quite sensitive to the skill level of the rural household members. Efforts to improve education in rural areas are expected to increase the off-farm labor supply as well as to accelerate the farm modernization process.

The off-farm labor supply elasticity with respect to the stock of farm machinery per hectare is 0.18. This means that a 10% increase in machinery investment increases the off-farm labor supply by about 2%. As labor-saving technology continues to reduce farm labor requirements, more farmers and especially small farmers are likely to find higher returns to their excess labor resources in off-farm work as opposed to intensifying their farming operations on a limited land base. Government subsidies for capital inputs such as machinery accelerate the rate at which this substitution occurs, creating both the opportunity and need for off-farm work.

Although this study examined several factors that were hypothesized as determinants of off-farm labor supply, further study is necessary to identify other factors such as personal and off-farm employment characteristics that may affect the labor supply. In addition, community and national level conditions such as unemployment rates also need to be examined to assess their impact on off-farm work.

Taiwan's recent experience along with that of other countries such as Japan strongly suggests that off-farm employment has contributed greatly to higher farm incomes among small farmers during the economic development process. Rural Taiwanese households unable to increase their income via larger farm size have substantially increased their incomes by utilizing their excess labor in the nonfarm sector.

The Taiwanese experience of increasing rural purchasing power through off-farm work challenges the conventional technology approach to solving the small farmer problem and the agricultural economists' traditional view of off-farm income as a "by-product" of farms. Development planners and researchers should place higher priority upon understanding this process and developing plans that deal specifically with it. The central issue is to decide what strategy should be adopted for rural households that have found that off-farm work is an optimal way to use household labor resources. Traditionally, a goal of agricultural policies has been to achieve an efficient agricultural sector that rewards farmers equitably in terms of aggregate income and household income. Policy approaches to part-time farming must consider the gains and losses in terms of equity and efficiency for the part-time farmers, the full-time farmers, and rural areas. This research has demonstrated that a substantial payoff exists for the part-time farmers. We feel that off-farm work alternatives for small farmers will permit governments to do more about low incomes and poverty in rural areas.

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The Validity of the Cobb-Douglas Specification in Taiwan's Developing Agriculture

J. T. Shih, L. J. Hushak, and N. Rask

This paper tests the specification of production functions within the context of Taiwan's developing agriculture. The Cobb-Douglas and the translog function that contain the Cobb-Douglas as a special case are the alternatives selected for the test. The translog function relaxes many restrictive properties of the Cobb-Douglas function without causing computational difficulties.[1] Statistical and economic considerations are used as criteria of empirical performance.

The translog function has been used as a second-order approximation to a general production function to measure technical change biases with many factors of production (Binswanger) and to test the existence of a consistent aggregate index of labor inputs (Berndt and Christensen 1974). Kmenta has considered it as an approximation to the constant elasticity of substitution. Griliches and Ringstad and Sargan are the only studies found that estimate the translog as a production function in its own right. Properties of the translog function are discussed in Berndt and Christensen (1973) and Christensen, Jorgensen, and Lau.

Data, Variables, and Models

The farm records kept by fifty-three Taiwanese farm families during the 1964–70 period provide the data for this study. The distinctive feature of combined cross-section time-series data is that they permit use of past histories of individual farms to isolate the effects of persistent interfarm differences in behavior. These data, which were generated from a farm-record-keeping project in Taiwan, include rather comprehensive information on land use, labor supplied, farm and nonfarm receipts, farm operating expenses, household living expenses, farm assets, liabilities, and net worth, but the absence of price information on farm outputs and inputs makes it impossible to consider simultaneous equations production models.[2] The nonrandomness of the sample and the small number of farms reduce the value of the estimated production functions for policy issues. The implications of the results from this study are limited primarily to methodological aspects.

Gross farm income is expressed as a function of a set of inputs. The factors that have been observed and that are hypothesized to be arguments in the production function are land, labor, capital services, and management as represented by farm dummy variables. Gross farm income (Y) is defined as the gross income from operation of farm enterprises, including receipts from crop, livestock, and poultry, processed farm products, and others. It is measured in New Taiwan dollars (NT$) of 1960–63 prices (Bureau of Accounting and Statistics, Taiwan).

Area cropped (X_1), measured in hectares, is defined as the total area cropped for first paddy plus second paddy plus other crops in a year. In Taiwan, a parcel of good land is usually cultivated two or three times a year, while land of low quality can be cultivated only once. In this case, the use of area cropped instead of area of farm land may to some extent increase the homogeneity of land input.[3]

Total labor (X_2), including family and hired labor, is measured in adult-man-days worked on farm enterprises. The weights used for conversion to adult-man-days are male aged 15 to 60 years is 1.0, male aged under 15 or over 60 years is 0.5, female aged 15 to 60 years is 0.8, and female aged under 15

J. T. Shih is at the Institute of Economics, Academia Sinica, Taiwan, and L. J. Hushak is an associate professor and N. Rask is a professor at the Ohio State University and the Ohio Agricultural Research and Development Center.

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[1] The constant-elasticity-of-substitution function (Arrow et al.), Mukerji's CRES (constant-ratio-of-elasticity-of-substitution) function, Clemhout's class of homothetic functions, and Revankar's VES (variable-elasticity-of-substitution) function are other alternatives. These functions, however, complicate statistical estimation. A modified Cobb-Douglas function (Ulveling and Fletcher) was tested and gave results closer to the translog function than the Cobb-Douglas.

[2] The Taiwan farm-record-keeping project is conducted by the Provincial Department of Agriculture and Forestry (PDAF). The project began coverage of the entire island in 1964. Farmers are free to enter or drop from the program at any time. There were only fifty-three farm families remaining in the project throughout the 1964–70 period. The total number of participating farm families ranged from 402 to 535 during this period. In 1971, only forty of the fifty-three farms were still in the project, and in 1972 only two. For a detailed description of the data, see Ong (pp. 40–61) and Shih (pp. 41–46).

[3] Three land variable alternatives were considered: total area of farm land, total area cropped, and the area of farm land in irrigated equivalents. To choose among these alternatives, their simple correlations with gross farm income were calculated. Crop area was chosen since it had the highest simple correlation.

or over 60 years is 0.4. The assumption implied by this specification of labor input is that the productivity of family workers is the same as that of comparable hired workers.

Capital services (X_3) is measured in NT$ of 1960–63 prices. Included are current expenses for seed and seedlings, fertilizers, wages to hired animal labor, insect and pest control, farm equipment, feed, and others. Also included are the imputed interest expenses and depreciation charges for farm buildings and farm machinery.[4]

In addition to land, labor, and capital, management is expected to play an important role in the process of farm production. No measure of management exists in the data. Following Hoch and Mundlak, the farm-specific index of technical efficiency measured by the residual from the estimated production function is used to estimate managerial and other differences across farms. The farm specific residuals are obtained from the coefficients of a set of farm dummy variables (D_n, $n = 1, 2, \ldots, 53$), where $D_n = 1$ for the nth farm and $D_n = 0$ otherwise.

This covariance model is selected over an error components model because the farm specific residuals are correlated with measured inputs. Although error components models are considered to be more efficient than fixed effects covariance models (Maddala), violation of a basic assumption of error components models (because managerial variations are included in the farm specific residuals) led to the choice of a fixed effects model.

The Cobb-Douglas model of Taiwan's production is

$$(1)\quad \ln Y_{nt} = \ln A + \sum_{i=1}^{3} a_i \ln X_{int} + \sum_{n=2}^{53} F_n D_n + u_{nt},$$

where n ($n = 1, 2, \ldots, 53$) stands for the individual farm, t ($t = 1, 2, \ldots, 7$) for the individual year, and i ($i = 1, 2, 3$) for the input, and u is the disturbance term. The intercept term $\ln A$ stands for the first ($n = 1$) farm whose dummy variable is suppressed. The F_n's are the farm dummy coefficients that, along with $\ln A$ and the a_i's, are to be estimated.

The translog model is

$$\begin{aligned}(2)\quad \ln y_{nt} &= \ln B + b_1 \ln Z_{1nt} + b_2 \ln Z_{2nt} \\ &\quad + b_3 \ln Z_{3nt} + 1/2 c_{11} (\ln Z_{1nt})^2 \\ &\quad + c_{12} \ln Z_{1nt} \ln Z_{2nt} + c_{13} \ln Z_{1nt} \ln Z_{3nt} \\ &\quad + 1/2 c_{22} (\ln Z_{2nt})^2 + c_{23} \ln Z_{2nt} \ln Z_{3nt} \\ &\quad + 1/2 c_{33} (\ln Z_{3nt})^2 + \sum_{n=2}^{53} G_n D_n + v_{nt},\end{aligned}$$

where $y_{nt} = Y_{nt}/Y^*$, $Z_{int} = X_{int}/X_i^*$, Y^* and X_i^* are the geometric means of Y and X_i, G_n are the farm dummy coefficients, and v is the disturbance term. All other terms are as previously defined. As these equations are all linear in the parameters, ordinary least squares can be applied.[5]

Testing of Functional Forms

Only the "best" estimate of the translog is tested against the Cobb-Douglas. The alternative equations are displayed in table 1. The farm dummy variables (D_n) are statistically significant at the 0.01 level in all equations, but the coefficients are not presented.

Selection of the "Best" Translog Model

The translog function (2a) includes all six squared and cross product terms. Only ($\ln X_1 \ln X_2$) and ($\ln X_2$)^2 have significant coefficients. The four vari-

[4] Since the concern in this study is with the specification of functional forms, all capital services were aggregated into a single capital service variable.

[5] A set of time dummy variables was also included as variants to models (1) and (2). The coefficients of the time variables were never significant, either individually or as a group, and are excluded from the models in this paper.

Table 1. Selected Fitted Regressions

	(1)	(2a)	(2b)	(2c)
$\ln X_1$	0.318	0.269	0.260	0.290
	(7.725)	(5.957)	(5.988)	(6.920)
$\ln X_2$	0.124	0.174	0.178	0.127
	(3.103)	(3.893)	(4.025)	(3.164)
$\ln X_3$	0.378	0.403	0.397	0.404
	(10.772)	(11.132)	(11.369)	(11.244)
$\ln X_1^2$	—	0.036	—	—
		(1.037)		
$\ln X_1 \ln X_2$	—	−0.269	−0.214	−0.120
		(3.525)	(3.612)	(2.658)
$\ln X_1 \ln X_3$	—	0.019	—	—
		(0.373)		
$\ln X_2^2$	—	0.175	0.169	—
		(2.523)	(3.171)	
$\ln X_2 \ln X_3$	—	0.038	—	0.087
		(0.609)		(2.212)
$\ln X_3^2$	—	−0.012	—	—
		(0.393)		
SEE	0.179	0.176	0.176	0.177
R^2	0.934	0.937	0.936	0.935
F-ratio	80.616	75.141	80.895	79.514
D.F.	55;315	61;309	57;313	57;313

Note: All equations include $\ln A$ and the D_n's. The variables are defined in the text. t-ratios are in parentheses. SEE is the standard error of estimate. D.F. is degrees of freedom.

ables with small t-ratios are dropped, and the coefficients of the retained variables in (2b) are similar to those in (2a).

Generally, the use of labor in farm production in a labor-surplus economy is greater than needed relative to other inputs. This implies diminishing marginal returns to increasing quantities of labor input (other input quantities being the same). The positive coefficients of the squared labor variable in models (2a) and (2b) are sufficiently large to make the second-order condition for labor positive when evaluated at the mean, implying increasing returns to labor. Although economic logic does not rule out this possibility, the estimated increasing marginal returns to labor in a developing economy characterized by labor-intensive agriculture is not expected.

The translog function is potentially subject to serious multicollinearity problems. Several alternative estimates were examined. Model (2c), where the labor-capital cross product ($\ln X_2 \ln X_3$) is substituted for the squared labor variable $(\ln X_2)^2$, is the only alternative estimate that yields significant coefficients of second-order variables. The simple correlation between $\ln X_2^2$ and $\ln X_2 \ln X_3$ is 0.89, the largest between any pair of explanatory variables. Since model (2c) is consistent with economic expectations, it is considered as the "best" model on statistical and economic grounds for comparison with the Cobb-Douglas function.

Comparison of Models (1) and (2)

For purposes of comparison, equation (1) is compared with (2c). In equation (1), all the estimated coefficients of the input variables have large t-ratios, but model (2c) has two additional terms whose coefficients have t-ratios greater than 2. Compared with model (1), model (2c) has a reduction in residual variance that is statistically significant at the 0.05 level. This is evidence that the Cobb-Douglas function is not appropriate.

The marginal productivity equations of input X_i for the Cobb-Douglas and translog functions, respectively, are

$$f_i = b_i \frac{Y}{X_i}, \text{ and } f_i = (b_i + \sum_{j=1}^{m} c_{ij} \ln Z_j) \frac{Y}{X_i}.$$

Following conventional procedures, the geometric mean of observed output and inputs in the sample is used as one computational point (table 2). The marginal product of each input at its mean level and at ±10% of its mean level is computed, holding other inputs constant at their mean levels. Then the sample farms are split into two groups based on mean outputs to obtain two additional points: one point above and one below the total sample mean. The value of production per farm, the amount of inputs used per farm, and the average value products of various inputs are reported in table 3 for the sample and the above and below the mean groups.

Because of the diminishing returns nature of the elasticity coefficients, the returns for the quantities of inputs used are the lowest at the 10% above the mean point and highest at the 10% below the mean point (table 2). For model (1), the marginal product of cropped area is NT$7,515 per hectare at the geometric mean of variables. It decreases to NT$7,049 per hectare when the cropped area is 10% above the mean level and increases to NT$8,085 per hectare when cropped area is 10% below the mean. The productivity change of cropped area at alternative levels for model (2c) can be seen across the second row of table 2.

The estimated marginal returns to labor from the two models are similar. Compared with model (2c), model (1) shows a higher return to cropped area and a lower return to capital services. Because of the constant-elasticity-of-production restriction of model (1), the computed marginal product of any input appears to be the "average" of varying production techniques. The constant-production-elasticity function tends to overstate the marginal returns to cropped area and understate returns to capital services for more capital-intensive techniques. The opposite is true for less capital-intensive techniques.

The marginal products of various inputs at three different combinations of input and output levels are presented in table 4. The marginal returns to land input are NT$7,110, NT$7,515, and NT$7,927 per hectare in model (1) at the geometric means for the below the mean, all, and above the mean groups of farms. In evaluating estimates of marginal returns, the emerging pattern is more in agreement with logic for model (2c) than for model (1). The two models show similar marginal products of

Table 2. Marginal Products with Varying Input Levels, All Farms

		Marginal Production at Input Level		
	Model	10%	Mean	−10%
Cropped area (NT$/ha.)	1	7,049.38	7,515.47	8,085.13
	2c	6,415.98	6,858.65	7,399.70
Labor (NT$/man-day)	1	12.07	13.11	14.39
	2c	12.37	13.44	14.74
Capital services (NT$/NT$)	1	0.84	0.89	0.95
	2c	0.90	0.95	1.01

Table 3. Value of Production, Quantity of Inputs, and Average Value Product of Inputs

		Farm Groups[a]		
		Below Mean	All Farms	Above Mean
No. of farms		26	53	27
No. of observations		182	371	189
Gross value of farm production per farm (NT$)	Observed	31,667.11	49,694.03	76,692.33
	Computed 1	31,941.36	—	76,058.10
	Computed 2c	32,121.19	—	77,533.03
Input per farm				
Cropped area (ha.)	X_1	1.43	2.10	3.05
Labor (man-day)	X_2	362.65	470.75	605.21
Capital services (NT$)	X_3	13,300.89	21,251.44	33,370.21
Average products				
Cropped area (NT$/ha.)	Observed	22,180.35	23,647.63	25,152.23
	Computed 1	22,372.44	—	24,944.23
	Computed 2c	22,498.40	—	25,427.95
Labor (NT$/man-day)	Observed	87.32	105.56	126.72
	Computed 1	88.08	—	125.67
	Computed 2c	88.57	—	128.11
Capital services (NT$/NT$)	Observed	2.38	2.34	2.30
	Computed 1	2.40	—	2.28
	Computed 2c	2.41	—	2.32

[a] The observed inputs and computed output are at the geometric means of the respective groups.

labor. Model (2c) shows a monotonic decrease in land productivity when moving from the lower to the higher combinations of input and output levels, while model (1) shows an increase. Conversely, model (2c) shows a monotonic increase in capital productivity from the smaller to the larger size levels, while model (1) shows a decrease. These results for model (2c) are attributable to the negative effect of the joint variable $\ln X_1 \ln X_2$ and the positive effect of the joint variable $\ln X_2 \ln X_3$.

Under the hypothesis that constant returns to scale prevail in farm production, the introduction of farm-specific dummies into the production models, if there are omitted variables such as management, results in a drop in the sum of output elasticities. The two models under comparison show such an elasticity drop. The scale elasticity of model (1) is 0.82. The scale elasticity in model (2c) is 0.84 at the small size group mean, 0.82 at the all farm mean, and 0.81 at the large size group mean.[6] The corresponding geometric means (antilogs of mean coefficients) of the farm specific residuals are 0.89, 1.0, and 1.12 from model (2c). This indicates that there may be a decrease in returns to scale from the included variables as size or scale increases because the excluded variables become relatively more important on larger farms.

In the translog model (2c), the Allen (p. 504) partial elasticities of substitution, computed at the

[6] The comparable scale elasticities for all farms when the farm dummy variables are deleted are 0.938 for model (1) and 0.983 for model (2c) at the sample geometric mean.

Table 4. Marginal Products at Varying Size Levels

			Farm Groups		
		Model	Below Mean	All Farms	Above Mean
Cropped area (NT$/ha.)	f_1	1	7,110.20	7,515.47	7,927.54
		2c	7,226.88	6,858.65	6.611.48
Labor (NT$/man-day)	f_2	1	10.94	13.11	15.61
		2c	11.76	13.44	15.63
Capital services (NT$/NT$)	f_3	1	0.91	0.89	0.86
		2c	0.92	0.95	0.99

sample geometric mean, are 6.23 for land-labor, 1.67 for land-capital, and −0.89 for labor-capital. The computed partial elasticities at the above and below the mean sample points are of similar sign and magnitude. These elasticities indicate a production technology that is relatively flexible with respect to land and labor use but very inflexible with respect to labor-capital use.

Conclusions

The translog model has two significant variables not in the Cobb-Douglas relation. Although these two models gave similar degrees of fit, the significance of two more variables in the alternative model can be accepted as evidence to reject the Cobb-Douglas specification.

When evaluated on economic grounds, the major difference is in the allocation of output to land and capital. The Cobb-Douglas shows a higher return to land and a lower return to capital services as compared with the translog. With respect to scale changes, the Cobb-Douglas shows increasing returns to land and decreasing returns to capital, while the translog shows the opposite. The restriction of constant-elasticity-of-production makes it impossible for the Cobb-Douglas to distinguish between land and capital productivity on farms with more capital-intensive techniques and farms with less capital-intensive techniques.

Further examination of productivity behavior from scale changes and changes in input proportions indicates that the translog model has advantages over the Cobb-Douglas model in two respects. First, the pattern of input productivity estimates for three different size groupings of farms appears to be more in agreement with expectations for the translog model than for the Cobb-Douglas. Second, in the translog model the output elasticity of various inputs is allowed to vary with size levels and to be determined by the data.

The "best" model emerging on economic and statistical grounds is a simplified form of the translog function. Specified in this manner, the chosen model of production is more similar in appearance to Vinod's multiplicative nonhomogeneous production function than to the original translog specification. Although nonhomogeneity is required by theory, the empirical fitting of nonhomogeneous production functions is uncommon. The results in this paper support the nonhomogeneous production laws.

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Land Utilization and Productivity in Prewar Chinese Agriculture: Preconditions for Collectivization

Dennis L. Chinn

The distinguishing feature of the strategy for agricultural development adopted in China after the Communist takeover was the rapid series of organizational changes that occurred. Following the land reform, mutual aid terms were organized, followed in rapid succession by elementary producer cooperatives, advanced producer cooperatives, and finally the rural communes.[1] Although estimates of grain output prior to the Great Leap Forward differ widely, it is generally agreed that China's agricultural performance during this early period was much better than that of many other developing countries.[2] The interesting and as yet unresolved question regarding that experience is the role that the organizational changes themselves played in raising output.

It is useful to conceptually distinguish several aspects of the causal relationship between the organizational changes and agricultural productivity. The official Chinese literature places primary emphasis on the labor mobilization aspect as the key to increased productivity through investments in land reclamation, irrigation, and agricultural infrastructure. The collectivization process was the mechanism by which increasingly large amounts of rural labor could be mobilized. A second closely related aspect of the relationship is the whole question of peasant incentives.[3] There is little doubt that the land reform raised the incomes of poor farmers by effectively eliminating the landlord class and allowing the peasants to capture the returns to the land and other assets, but the extent to which widespread increases in productivity directly resulted in China is unclear. Private land ownership was eliminated with the formation of the advanced producer cooperatives, so it would seem that those arguments that attribute substantial benefits to the incentives created by the establishment of individual property rights by land reform are not applicable to the present case. (For a survey of the literature on land reform and its effects, see Raup.) To the extent that landlord control was simply replaced after a few years by state control, one could hardly argue that elimination of the former significantly improved production incentives in the long run.

The present paper concerns a third aspect of the relationship between changes in organization and productivity, the extent to which static efficiency gains result from the induced reallocation of resources. The land reform consolidated fragmented holdings and effectively eliminated tenancy, transferring ownership from landlords to former tenants and poor peasant farm households; the formation of mutual aid teams formalized and extended cooperation between farm households in the use of labor, work animals, and capital implements; and the formation of the cooperatives increased the effective size of operational units substantially. Using data on prewar China, a simple regression analysis is used to relate tenancy, fragmentation of landholdings, and farm size to agricultural output in order to assess the potential for efficiency gains that existed prior to the Communist takeover and reorganization of agriculture. The existence of such potential would seem to be a necessary condition for significant static efficiency gains to result from organizational changes.

The organization of the paper is as follows. After a brief discussion of some characteristics of land utilization in prewar China, the method of analysis is described, the variables defined, and the statistical results presented. The final section of the paper relates the results to results of a previous complementary study and offers some tentative conclusions.

Land Utilization in Prewar China

Summary data on the pattern of land utilization for eight agricultural areas of China are presented in

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Dennis L. Chinn is an assistant professor at the Food Research Institute, Stanford University.

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[1] For a concise description and chronology of the stages in the collectivization process in China during this period, see Walker. The analysis of this paper focuses on the general cumulative effects of all stages together rather than chronological details or effects specific to each stage in isolation.

[2] All western observers seem to agree that the official figure for total grain output in China for 1957 of 185 million tons is accurate. However, estimates for 1952 range from 175 million tons to acceptance of the official Chinese estimate of 154 million tons. Thus, depending upon which base figure one takes, during 1952–57 grain output in China increased by anywhere between 5.7% and 20.1%. For a summary of the available estimates, see Sinha.

[3] The development of various wage payment schemes with the objective of maintaining production incentives through payment according to work while reducing income differentials is quite fascinating. See Hoffman for a description of these mechanisms.

table 1. The area averages summarize detailed survey data for 16,786 Chinese farm households collected by Buck (1937) and his associates during 1929–33. Several points warrant mention. First, due to high population pressure, the average size of farm is extremely small, especially in the rice areas. The average farm size for the wheat area as a whole is 2.28 hectares, while that for the rice area is only 1.25 hectares. In each area over 90% of the total land area is in productive use. The difference in total area sown is somewhat less than the difference in farm size, as multiple cropping is more prevalent in the rice area.

Second, fragmentation of landholdings is an extremely severe problem in both the rice and wheat areas. The average farm in each area consists of more than five separate parcels of land separated by the average distance of 0.8 kilometer in the wheat area and 0.5 kilometer in the rice area. Third, tenancy is much more extensive in the rice area than in the wheat area. In the former, 40% of all land is rented as compared with only 13% in the wheat area. For the households surveyed by Buck, 6% of farmers in the wheat area and 25% in the rice area are tenants. These figures are considerably lower than the corresponding figures from National Agricultural Research Bureau (NARB) data of 17% and 46%, respectively, as shown in table 1. This discrepancy suggests that tenant farmers may be underrepresented in Buck's samples, so the estimated relationships that follow cannot be interpreted as being necessarily representative of all farms in each crop area.

Finally, there is substantial variation in the pattern of land utilization within the wheat and rice areas as well as between the two. For example, the average farm size in the spring wheat area is almost twice that in the winter wheat-millet area, while the percentage of land rented in the latter is twice that in the former. Variation in the pattern of land utilization within the rice area is also significant, suggesting that attempts to generalize about Chinese agriculture as a whole should be taken with a somewhat larger than average grain of salt.

Method of Analysis

For present purposes traditional Chinese agriculture is represented by the simple Cobb-Douglas production function

$$(1) \qquad Q = AM^aN^bL^cZ^d,$$

where Q is total output, A is a constant term, M is the index of multiple cropping, N is total land area in productive use, L is family labor input into farming, and Z is organic fertilizer.[4] The lower case letters represent the constant elasticities of output with respect to the individual inputs. The index of multiple cropping is interpreted as an index of technical progress and is closely related to the availability of controlled water supplies in areas climatically suitable for double cropping. The rationale for including M as a separate variable rather than simply using total sown area (MN) in place of N as the land variable is that my interest is in changes in the

[4] Other traditional inputs in Chinese agriculture are animal labor and tools of various kinds. However, since suitable data are not available for the sample households, these inputs are not included in the analysis. In any case, the available ownership figures for productive animals are highly correlated with the fertilizer input variable.

Table 1. Characteristics of Land Utilization for Sample Households in Prewar China by Crop Areas

Crop Areas of China	Average Size of Farm (Ha.)	Percentage of Farm Land in Productive Use[a]	Multiple Cropping Index[b]	Fragmentation		Tenancy		
				Number of Parcels per Farm	Average Distance Between Parcels (Km.)	Percentage of Land Rented	Percentage of Farmers Who Are Tenants	
							Buck[c]	NARB[d]
Wheat area	2.28	93.1	127	5.7	0.8	12.7	6.3	17.2
Spring wheat	3.25	90.7	107	4.8	1.0	8.4	5.7	38.9
Winter wheat-millet	1.71	93.1	118	5.5	0.9	17.3	8.9	16.4
Winter wheat-kaoliang	2.25	93.8	139	6.2	0.6	11.8	5.1	12.1
Rice area	1.25	92.4	166	5.5	0.5	40.3	24.6	46.3
Yangtze rice-wheat	1.56	92.8	165	5.3	0.3	39.4	25.1	48.9
Rice-tea	1.00	94.0	169	5.4	0.6	42.1	18.5	48.9
Szechwan rice	1.43	91.3	167	9.7	0.3	49.1	43.1	51.4
Double-cropping rice	0.96	92.5	176	5.4	0.7	46.8	28.2	46.2
Southwestern rice	1.03	88.4	152	3.7	0.6	26.8	21.0	36.4

Note: Data from Buck (1937, tables 15, 21, 22, chapter II, and table 5, chapter VII).

[a] Includes crop land, pasture, forest, productive water area, and land in brush and grass used for fuel. Excludes the farmstead, land taken by roads, ponds, graves, etc., and arable uncultivated land.

[b] Calculated as the total area that would be required to produce the actual output levels for all crops at the most frequent yields in China divided by the area actually required to produce the crops in the locality multiplied by 100.

[c] Farmers who own their farmstead but rent all their crop land are included as tenants.

[d] Source: National Agricultural Research Board.

pattern of utilization of land area rather than area sown to crops.

Assessing the effects of fragmentation of landholdings and tenancy on agricultural output involves two hypotheses. First, fragmentation and tenancy are negatively correlated with family labor input per hectare of land. The greater is land fragmentation and the higher the proportion of land rented, the lower will be the relative rewards to farming, and the farm household's response will be to increase labor allocated to off-farm activities and/or leisure. Second, fragmentation and tenancy are negatively correlated with total factor productivity. Increasing fragmentation and tenancy will tend to shift the production function downward.

The test of these two hypotheses in the present context is straightforward, involving the estimation of two sets of log-linear regression equations:

$$(2)\quad \log (L/N) = \log B + \alpha \log M + \beta \log F + \gamma \log T,$$

and

$$(3)\quad \log Q = \log A + a \log M + (b + c + d) \log N + c \log (L/N) + d \log (Z/N) + e \log F + f \log T.$$

In the first set, equation (2), family labor input per hectare of land is related to a constant term B, the index of multiple cropping M, an index of land fragmentation F, and an index of tenancy T. Based on the first hypothesis, both β and γ are expected to be negative. In the production function (3), the fragmentation F and tenancy T variables simply enter as additional terms. Whether they are entered multiplicatively (additively in logs) or additively turns out to make little difference to the empirical results, but the form used embodies the implicit assumption that a given percentage change in either the tenancy or fragmentation indices has the same effect on output over all values of the indices.[5] Based on the second hypothesis, the expectation is that e and f be negative. The traditional inputs labor L and organic fertilizer Z are measured in per hectare terms, so the coefficient of log N in the production function $b + c + d$ can be interpreted as the returns to scale parameter.

Number of Observations and Variable Definitions

In the statistical volume of Buck's study (1937), averages of individual farm survey data are given for relative farm size classes by individual localities for each of the eight agricultural areas of China listed in table 1. For the spring wheat area, for example, average data are given for surveyed farms in thirteen localities (in six provinces) for eight farm size classes, giving potentially 104 observations for cross-section analysis. However, some localities have to be omitted due to omissions in the data, and the smallest and two largest farm size classes are simply not represented for most localities. As a result, the total number of observations for the spring wheat area is only seventy-one. The sample size for each area is given in table 2.

The variables used in the analysis are defined as follows. Total output Q is total output per farm in grain-equivalent units, the land variable N is hectares of land in productive use, excluding the farmstead, land taken by roads, ponds and graves, and arable uncultivated land, and the index of multiple cropping M is calculated as the total area that would be required to produce the actual output levels for all crops at the most frequent yields divided by the area actually required to produce the crops in the locality (times 100).

Suitable data on farm household labor allocation are not available, so the labor variable L is constructed as the following product: (number of male adult equivalent units) × (12 − number of idle months per able-bodied man) × (the proportion of total income earned from farm sources). The second term adjusts for idleness by choice or due to lack of alternative opportunities, and the last term reflects the allocation of labor between farm and off-farm activities. The implicit assumption is that an equilibrium position is reached by farm households in which the per unit returns to labor in farm and off-farm activities are roughly equivalent, so the proportions in total income reflect the allocation of family labor. This is somewhat arbitrary, but given the available data this assumption cannot be avoided.

The fertilizer variable Z is the total amount of animal manure and night soil applied per farm. Since traditional fertilizer application is little more than embodied labor, the two input variables are highly correlated, so at most one of the two is entered in each estimated production function. The fragmentation index F reflects both the number of parcels per farm and the average distance between parcels and is defined as the product of the two, and the index of tenancy T is simply the proportion of farm land rented.

Statistical Results

The first set of estimated equations, equation (2), is presented in table 2 with t-statistics in parentheses.[6] The most striking result is that the index of fragmentation F is a significant and negative explanatory variable for each equation, except that for the Szechwan rice area for which the statistical results are totally unsatisfactory due to the small number

[5] The formulation of the production function used here is the same as that used in a recent analysis of Indian data. For a discussion of the difficulties involved in estimating such a function, see Bardhan.

[6] A set of dummy variables was included in each equation in order to reflect any systematic differences between provinces, but since they had little effect on the regression results their coefficients are not reported.

Table 2. Estimated Regression Equation with Labor Input per Hectare (L/N) as Dependent Variable for Prewar China by Crop Areas

Crop Areas of China	Constant (A)	Multiple Cropping Index (M)	Fragmentation Index (F)	Tenancy Index (T)	R^2	Number of Observations
Spring wheat	2.741	—	−0.464	—	0.519	71
			(−6.62)			
Winter wheat-millet	−7.301	2.033	−0.154	—	0.398	97
		(5.27)	(−2.27)			
Winter wheat-kaoliang	3.110	—	−0.442	—	0.388	168
			(−8.97)			
Yangtze rice-wheat	−2.278	1.041	−0.170	−0.116	0.288	132
		(4.88)	(−3.52)	(−2.61)		
Rice-tea	−0.210	0.623	−0.209	—	0.373	107
		(4.78)	(−4.84)			
Szechwan rice	3.065	—	—	—	0.019	35
Double-cropping rice	3.580	—	−0.286	—	0.343	60
			(−4.15)			
Southwestern rice	−1.216	0.917	−0.473	—	0.599	55
		(3.34)	(−4.92)			

Note: All variables are measured in natural logarithms.

of observations. Thus, the widespread severe fragmentation of landholdings was clearly an important determinant of household labor allocation behavior in prewar China. On the other hand, for all but one area the tenancy variable T is not significant, suggesting that renting land did not strongly inhibit households from allocating labor to farming.

The estimated production functions are presented in table 3. The coefficient of the index of multiple cropping M is positive and significant for five of the eight areas, and the coefficient of the land variable N is positive and significant for all. The coefficient for either labor L or fertilizer Z is positive and significant for each equation, with the exception of that for the Yangtze rice-wheat area for which neither is significant. The coefficient of the land variable N exceeds unity for all areas except the Yangtze rice-wheat area, suggesting that in some areas increasing the size of farm units through reorganization would indeed result in increased output through scale effects.

Entering the fragmentation index F and the tenancy variable T as independent variables in the production function yields somewhat inconclusive results. The fragmentation index is significant and negative for four of the areas, suggesting that the

Table 3. Estimated Agricultural Production Functions for Prewar China by Crop Areas

Crop Areas of China	Constant (A)	Multiple Cropping Index (M)	Land in Productive Use[a] (N)	Labor Input per Hectare (L/N)	Fertilizer Application per Hectare (Z/N)	Fragmentation Index (F)	Tenancy Index (T)	R^2
Spring wheat	5.934	—	1.025	0.312	—	—	—	0.842
			(11.36)	(1.88)				
Winter wheat-millet	4.636	—	1.036	—	0.298	−0.116	−0.041	0.868
			(16.46)		(3.02)	(−1.88)	(−2.69)	
Winter wheat-kaoliang	1.786	0.909	1.219	0.511	—	−0.177	—	0.802
		(3.12)	(15.49)	(4.52)		(−2.73)		
Yangtze rice-wheat	−3.800	2.223	0.910	—	—	—	—	0.644
		(7.58)	(13.89)					
Rice-tea	4.305	0.598	1.104	0.187	—	−0.072	—	0.936
		(7.53)	(29.23)	(2.89)		(−2.62)		
Szechwan rice	5.088	—	1.379	0.987	—	—	—	0.843
			(11.69)	(4.52)				
Double-cropping rice	3.459	0.569	1.135	0.464	—	—	—	0.926
		(3.17)	(12.99)	(3.65)				
Southwestern rice	1.626	0.636	1.058	—	0.358	−0.199	—	0.863
		(2.53)	(13.94)		(4.70)	(−2.11)		

Note: All variables are measured in natural logarithms.
[a] Coefficient is returns to scale parameter.

excessive fragmentation did inhibit total factor productivity in at least some areas. However, as in the first set of estimated equations, the tenancy variable is significant for only one of the areas, suggesting that the percentage of land rented was not a severe limitation on productivity.

The lack of statistical significance of the tenancy variable in both sets of equations presented above may in part reflect the fact that the percentage of land rented does not reflect the degree of exploitation involved in the tenancy arrangement or the conditions under which tenant farm families were forced to live and also the possibility that tenant farms were underrepresented in the sample data on which those equations are based. Nonetheless, the lack of significance of the tenancy index is not inconsistent with the results of prewar studies on farm tenancy in China. In a study that summarizes the results of numerous prewar surveys, Buck (1944) compares tenant farms and owner-operated farms of similar size and concludes that yield per unit of land area did not differ systematically between the two, that although total incomes of owner-operators were higher, tenant farmers earned substantially more labor returns per man-equivalent unit through more intensive application of labor, and that the landlord's share of total receipts did not systematically exceed the proportion of inputs he supplied. The samples on which he bases those conclusions were by no means comprehensive, but there is little one can do about that now.

Complementary Results and Some Tentative Conclusions

A recent study by Dittrich and Myers provides evidence on a different aspect of potential static efficiency gains from resource reallocation that is complementary to the above results. Their study uses detailed farm family budget data for three villages in the grain-producing area of north China between 1937 and 1940 to estimate the potential gain in crop revenue by reallocating factors of production between individual crops. Their procedure is to estimate marginal products of labor and land by estimating production functions for individual crops and then to simulate resource reallocation in order to equalize marginal products across crops. The difference between the actual total crop revenues per farm and the potential revenues that would obtain if factors were optimally allocated then represents the potential gain in crop revenue from resource reallocation between crops. As a percentage of actual average farm income, with the exception of one village in 1939, the potential income gain was quite small, ranging from 1.4% to 9.6%.[7] On the basis of their evidence, they conclude that peasant farmers in the region studied were fairly efficient in allocating their labor and land resources between alternative crops.

A second result that stems from their production function estimates is that in two of the three villages considered cotton, corn, sorghum, wheat, and millet production were generally characterized by increasing returns to scale. In the third village, cotton, wheat, and millet were found to be characterized by decreasing returns to scale, so this evidence is by no means conclusive. Nonetheless, even though individual farms do not appear to have suffered much loss of potential income due to resource misallocation between crops, for two of the three villages studied it does appear that productivity gains would have resulted from increased specialization.

The evidence presented by Dittrich and Myers and the statistical results of the present paper suggest that agricultural productivity in prewar China was constrained by excessive fragmentation and small farm size. Following the Communist takeover, these constraints were released by the land reform and the formation of agricultural cooperatives. Whether or not the elimination of tenancy resulted in significant static productivity gains is less clear. The results of the present paper, while highly tentative, do suggest that in most areas of China the potential static efficiency gains from eliminating tenancy per se were small.

The analysis of this paper is relevant to only one aspect of the relationship between productivity and organizational structure in Chinese agriculture. Land reform and the changes that followed restructured Chinese rural society and set in motion powerful dynamic forces that undoubtedly had strong effects on peasant incentives. Whether on balance agricultural productivity increased as a result of the organizational changes depends upon the responses of peasant households to changes in the incentive structure facing them. Unfortunately, due to the rudimentary state of our knowledge in this area, whether one holds that agricultural productivity increased in China during 1949–57 as a direct result of, or in spite of, the organizational changes seems to turn on ideological conviction rather than historical evidence. While ideological conviction is the stuff by which mountains are moved in China as elsewhere, it would seem wise to keep it and economic analysis separate to the extent possible, even if that means substantive conclusions cannot be drawn.

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[7] The exception is a loss of potential income in one village for 1939 of 17.5% of actual income due to rapid price inflation. This result presumably reflects the fact that production adjustments are not instantaneous.

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Social Return to U.S. Technical Assistance in Bolivian Agriculture: The Case of Sheep and Wheat

E. Boyd Wennergren and Morris D. Whitaker

Official U.S. technical assistance to the developing world has been a relatively important social investment in the post-World War II era. Approximately $4.7 billion was spent between 1949–72 in agriculture, health, and education by the U.S. Agency for International Development (USAID) and predecessor agencies (USAID, p. 47). In 1972, USAID allocated $103 million to programs in food and agriculture (p. 28), more than 20% of the amount spent on public research programs in U.S. agriculture for the same year (Boyce and Evenson, p. 152). Yet, despite the relative importance of technical assistance and the close involvement of agricultural economists, there has been extremely limited evaluation of the efficiency of society's investment in these relatively costly aid programs.[1]

This note reports estimates of the return to U.S. investment of $4.6 million in a technical assistance program in Bolivia's agricultural sector between 1965 and 1974. A brief history and the principal features of the program are presented in the next section. The efficiency of public U.S. investment in the two principal program components, the sheep and wheat projects, is then analyzed using a conventional benefit-cost model. Conclusions and the implications of the findings are considered in the final section.

The Technical Assistance Program

In July 1965, USAID contracted with Utah State University to provide technical assistance to MACA (Bolivia's Ministry of Agriculture) and related government agencies. (The material in this section is abstracted from a bulletin on the technical assistance program [Utah State University].) The general objective was to assist with economic development of the highland areas, where sheep, llama, and alpaca were the principal agricultural enterprises.

Several interrelated programs, jointly known as the sheep project and designed to increase production and marketing of livestock products, were initiated in 1965 through MACA and continued with varying degrees of emphasis throughout the life of the contract. Included were (*a*) introducing improved management practices in native herds, (*b*) upgrading the genetic base in livestock, (*c*) increasing forage production, and (*d*) improving and developing product markets. Principal components of each program included applied research and extension, institution building in the public and private sector, training of counterparts, and importations of requisite equipment and materials.

During the first year, two principal areas were emphasized. First, an extensive training-demonstration program was mounted to teach campesinos (farmers) to regularly shear their animals with hand clippers. Second, a semigovernmental buying system for wool, alpaca, and llama hair was organized, and quality grading and differential pricing of raw wool were instituted for the first time in Bolivia.

Between 1967 and 1969, the shearing and wool-marketing programs were relatively successful, and emphasis of the sheep project shifted toward introducing other improved management practices (besides shearing), improving the genetic base, and increasing forage production. By 1975, several improved management practices had been demonstrated and introduced with varying degrees of success, including ram and ewe selection for breeding, culling, record keeping, dipping and parasite control, diagnosis and treatment of common diseases, flushing, and fattening with supplemental feeds.

The program for improvement of the genetic base concentrated on importation of pure-blooded rams and ewes and the development of "ram-raiser" flocks. As domestic production of pure-blooded and improved rams increased, these rams were placed in native herds in a complementary exchange and improved management program. Demand for improved rams increased rapidly, and, toward the end of the contract, placement was almost completely through weekly village markets.

The program to increase forage production included introduction of selected crop and pasture varieties and improvement of management practices on native rangelands. Until 1973, emphasis

E. Boyd Wennergren is a professor of resource economics and Morris D. Whitaker is an associate professor of economics at Utah State University.

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[1] For example, in chapter 3 of their monograph, Boyce and Evenson consider "International Aid and National and International Research Programs" but devote only two pages to international aid to national systems.

was on selection of adaptable forage species through variety trials and importation and distribution of seeds (especially alfalfa) for commercial use. In 1973, efforts to improve range and watershed management were greatly increased and became the most important aspect of the forage production program until contract termination in 1975.

In mid-1966, the contract was amended to include a cereals project that concentrated on wheat production and marketing in the temperate valleys and later the lowlands. The initial focus of the wheat project was on variety and fertilizer response trials and extension of results. Also, the problems inherent in initiating a seed certification program were studied and recommendations made.

In 1969, the contract was amended to increase staffing from five to eight advisors, and the magnitude of the wheat project greatly expanded relative to the sheep project. Advisory personnel assigned to the wheat project increased from one and one-half to six, and a seed certification program was implemented. In 1971, one of the advisory positions on the wheat project was shifted back to sheep, and five advisors in wheat and three in sheep were maintained until contract termination in 1975.

Benefits and Costs

Conventional benefit-cost procedures are used to estimate the rate of return to U.S. investment in the sheep and wheat projects. Benefits are defined as the marginal net return accruing directly to individual farmers adopting new technologies under the program and do not include secondary benefits. Marginal net returns are calculated by subtracting the gross returns that would prevail without the program and the increased costs of production associated with adopting the new technology from the gross returns realized with the program. The opportunity cost of family labor is assumed to be zero in calculating increased costs of production, so marginal net returns are to management and family labor.

Program costs are the direct costs of the sheep and wheat projects paid by USAID for the contractor's services and do not include costs of the Government of Bolivia. Thus, the rate of return is to marginal U.S. investment in the technical assistance program rather than to total U.S.-Government of Bolivia costs, and increases in net returns experienced by farmers are assumed to be completely due to the marginal U.S. investment. This assumption is based on two observations. (*a*) MACA's total budget declined in real terms during the life of the contract with no evidence of significant internal shifts in favor of efforts in sheep and wheat with the advent of the technical assistance program. (*b*) Previous MACA efforts to increase factor productivity and production of sheep and wheat were relatively ineffective (Wennergren and Whitaker 1975a, p. 210, pp. 253–55).

Data used to calculate benefits and costs are taken from the extensive publications and reports produced under the technical assistance program (more than 233 titles exist),[2] the USAID contracts and their amendments, and unpublished data from MACA and are reported in Wennergren (1974, 1975). All benefits and costs are valued at 1974 prices.

The internal rate of return is used to measure social returns to investment in the technical assistance program and is calculated for the sheep, wheat, and combined projects. In each case, an *ex post facto* analysis is made for the period 1966–75 (fiscal years starting 1 August 1965) based on estimated benefits already realized. The technical assistance program is also analyzed assuming a twenty-year project life (1966–85) under two sets of conditions: (*a*) conservative, with benefits yet to be realized during 1976–85 assumed constant in each year at the level observed for 1975; and (*b*) more liberal, with benefits in 1976–85 extrapolated from the 1966–75 experience. These twenty-year "mid-project" analyses are made to determine the sensitivity of the internal rate of return to benefits yet to be realized.

Benefits from investment in the technical assistance program could be quantified for four distinct phases of the sheep project—wool shearing, production of pure-blooded sires, upgrading the genetic base and management practices in native flocks, and alfalfa production—and for one phase of the wheat project—introduction of improved wheat varieties. In each phase, increases in net returns to farmers due to program investment are estimated for 1966–75 and projected for 1976–85.

Benefits included in the wool-shearing phase are from the increased production of wool from unimproved sheep not accounted for in other phases of the sheep project. More than 200 sheep-shearing courses and demonstrations were conducted by contract technicians principally for training village leaders, extension agents, and Peace Corps volunteers. Unfortunately, no accurate record exists of the total number of campesinos trained by these people. However, records of the contractor indicate that 1,912 pairs of hand clippers were distributed by December 1967, 4,200 pairs by 1975, and that an average of 200 head of sheep were shorn per year per pair of clippers. Production of wool per sheep was increased from 1.1 to 4.0 kilos per five years because sheep were shorn every year rather than once in their lifetime. Costs of shearing were increased by $0.20 per kilo.[3]

To calculate gross returns with the project, it is assumed that the 4,200 clippers were distributed at the rate of 420 per year starting in fiscal year 1966 and that 150 head of sheep were shorn per year with

[2] A complete list of such publications can be obtained from the authors.

[3] In calculating increased private costs of adopting new techniques in each phase, all capital items are amortized at 12%, the bank rate of interest in Bolivia for agricultural credit.

each pair. For the period 1976–85, it is assumed the number of clippers in use remained constant at 4,200 with only replacement. Finally, it is assumed that all sheep in the other phases of the project were sheared, thus restricting the number of clippers available for shearing other unimproved flocks. The wool clipped from such unimproved sheep with the project minus the amount that would have been clipped without the project estimates increased production of wool due to the project. This, minus the increased costs due to the new technology, is the marginal net return to the wool-shearing phase of the sheep project.

The production of pure-blooded sires generated project benefits principally from the sale of seven-eighths to pure-blooded rams to be placed in native flocks and also from increased production of wool (both from annual shearing and improved genetics) and meat. Gross returns with the project are estimated by developing an animal and product inventory for each year of the analysis based on the total number of improved and pure-blooded sheep (1,500 ewes and 60 rams) in the limited number of flocks producing breeding stock in the initial year 1967, the lambing and death rates in such flocks with improved management, and yields of marketable rams, cullable rams and ewes, and wool.[4] Then, the animal and product inventory in native herds producing wool and slaughter animals is calculated starting with the same number of animals in 1967 as with the project to estimate gross returns without the project. Finally, the increased costs associated with producing breeding stock under improved management are calculated. Included are costs of pure-blooded rams and ewes, dipping, disease and parasite control, shearing, supplemental feeding, and the opportunity cost on capital.

Placement of seven-eighths to pure-blooded rams in native flocks and implementation of improved management practices (including shearing) resulted in increased production of wool and meat. Gross returns with and without this phase of the project are calculated in a similar manner to those for the pure-blooded sires phase through development of animal and product inventories. The number of pure-blooded rams initially available (283 in 1968) establishes the number of selected native ewes that could be bred and the subsequent inventory with the project. Increased costs of production for flock improvement include the pure-blooded rams, dipping, disease control, shearing, and the opportunity cost of capital. There is no increased cost for feed, since it is assumed that animals were pastured on native rangelands and that every improved blood ewe incorporated into the flock resulted in the sale of 1.5 native ewes (the crosses required more feed).

The alfalfa-production phase of the sheep project produced benefits from production of alfalfa on land that had previously been used to graze sheep on natural pastures. Gross returns to the project are from the sale of alfalfa produced on dry and irrigated land. The actual level of production in each year is based on the number of hectares and yields as reported in unpublished data of MACA. Gross returns without the project are from production of wool and slaughter animals under traditional conditions that are the same as those for the flock improvement phase but expressed on a per hectare basis. Increased costs of production include land clearing, land preparation, seed, hired labor, the opportunity cost of capital, and the cost of irrigation where applicable.

The only phase of the wheat project that permits quantification of benefits is the introduction of improved wheat varieties and cultural practices. Seed from selected improved varieties were multiplied and distributed to farmers through the seed certification program. Benefits are calculated as follows. Gross revenue per hectare with the project is based on average yields (1,000 kilos per hectare) realized on farms using improved varieties and management. Gross revenue per hectare without the project is based on average yields (750 kilos per hectare) on farms using traditional management and native varieties. Increased costs per hectare with the project include improved seed, hired labor, pesticides and herbicides, harvesting, sacks, transportation, and the opportunity cost of capital. Total benefits to the wheat project are the marginal net returns per hectare times the number of hectares actually planted to improved seed each year, which is obtained from bulletins and reports of the contractor.

Project costs are reported only for the combined sheep and wheat projects until 1971 and by uneven budget periods during the entire technical assistance program. The expenditures for each project during 1 August 1965 through 30 November 1969 are estimated based on the share of technical personnel in each project, since only total expenditures are reported. There are budgets for each project during 1 December 1969 through 28 February 1971, but only total expenditures are reported. Expenditures for each project in this period are estimated by the share of each project in the total budget. Expenditures by budget period for each project are converted to average annual expenditures for each fiscal year and deflated by the U.S. wholesale price index on a 1974 base. It is assumed that contract expenditures and program benefits are realized at the end of each fiscal year.

Rate of Return

The internal rate of return for the sheep project after ten years is 44.1% (table 1). When projected benefits for 1976–85 are held constant at 1975 level,

[4] This procedure was followed because of discontinuities in data on animals in flocks producing breeding stock. The projected 1974 inventory was 4,598 lambs. This is corroborated by a MACA estimate of 4,000 pure-blooded lambs produced in 1974.

Table 1. Internal Rates of Return to Sheep and Wheat Projects

Project Life	Sheep	Wheat	Total
		-----%-----	
1966–75	44.1	−47.5	31.7
1966–85[a]	49.7	14.1	41.2
1966–85[b]	51.5	[c]	43.2

[a] Benefits during 1976–85 held constant at 1975 levels.
[b] Benefits during 1976–85 increasing based on extrapolation from the 1966–75 experience.
[c] Not estimated as yields and area planted to improved wheat are not expected to increase significantly during 1976–85 because of project investment.

the return increased to 49.7% annually and is only 51.5% with benefits projected to increase during 1976–85. Thus, the rate of return is relatively insensitive to projected benefits in the twenty-year "midproject" analyses.

In contrast, the *ex post facto* return to public investment in the wheat project is negative at −47.5%. However, the rate of return is very sensitive to benefits yet to be realized. In the "midproject" analysis with benefits held constant at 1975 levels for 1976–85, the rate of return increased to 14.1%. Thus, the social profitability of the wheat project depends on future benefits being generated.

The combined projects generate a rate of return of 31.7% in the ten-year analysis, reflecting the relative importance of benefits of the sheep project. With benefits held constant at 1975 levels for 1976–85, the rate increased to 41.2% and is 43.2% when benefits increased according to projected trends during 1976–85.

Conclusions and Implications

One conclusion is that returns to U.S. investment in the sheep project are relatively high, although no directly comparable studies are at hand. However, the rates of return are in the range of returns to investment in research and extension programs, which have been previously reported (21% to 96%—see Arndt and Ruttan).

Furthermore, a number of activities were carried out under the sheep and wheat projects that generated social benefits that, for lack of data, could not be quantified in the above analysis. Perhaps the more important were a formal local training program; assistance in marketing wool, artisan products, and wheat; and assistance in developing a viable data base, carrying out economic and social policy studies, and developing agricultural plans. For example, under the training program, thirteen people were trained to the M.S. and Ph.D. level, two to the B.S. level, and fifty-one attended intensive courses all in the United States. Thus, the benefits from project investment are likely understated.

A second conclusion is that programming of U.S. investment in technical assistance for Bolivia's agriculture has resulted in a serious misallocation of resources. Investment in technical assistance programs generates benefits that are captured by citizens of developing countries—relatively poor campesinos in Bolivia's Altiplano and valleys in the case of the sheep and wheat projects. While U.S. technical assistance may be viewed as essentially a transfer program, the relatively large sums spent to develop and monitor programs in each recipient country suggests concern for efficient use of technical assistance resources, although political motivations may be very strong.

In any case, Bolivian society suffered real losses due to the initial decision to invest in the wheat project, especially because of greatly increased emphasis on this program in preference to the much more successful sheep project. In essence, the return to total U.S. investment was reduced by investment in the wheat project.

Early in 1966, contract consultants thoroughly studied the economic and agronomic potential for a wheat program. They concluded such a program would encounter serious difficulties because production of wheat was clearly uneconomic compared with other crops (Gardner 1966, Dewey and McAllister). In 1968, Gardner argued that a significant reduction in Bolivia's relatively large imports of wheat is possible within a ten-year period if improved varieties, which have produced relatively high yields under experimental conditions in Bolivia, could be generally extended to farmers. His analysis indicates that, for wheat to become competitive with other crops, yields at the farm level have to double. Also, land area in wheat would have to double, and more than 80% of all land in wheat would have to be planted to improved varieties in order for imports to be reduced by 50% in ten years.

Despite the pessimistic 1966 report of the consultants, the wheat project was added to the technical assistance program late in the same year. Then, in 1969, the USAID mission director and rural development officer were changed; shortly thereafter, the wheat project was significantly expanded without adequate testing of campesino acceptance of improved varieties or the probability of their widespread diffusion. We have argued elsewhere that rotation of USAID personnel tends to promote changes in program emphasis (Wennergren and Whitaker 1975b). Bolivia is a case in point. The contract focus on wheat was precipitately increased relative to sheep, and $1.8 million was spent on the wheat project between 1970–73 compared with $0.4 million in the previous four years.[5]

[5] In 1973, mission leadership again changed, the sheep and wheat projects were subsequently phased out, and a new technical assistance and loan program was implemented for improved sector management and research and extension in the valleys and lowlands, despite contrary advice from contract advisors.

The implications of this study are two-fold. First, investment in technical assistance can yield relatively high rates of return and can be an important instrument for increasing agricultural production and productivity and ultimately incomes and well-being for the relatively large number of rural poor in developing countries. Second, when programming decisions do not adhere to acceptable economic criteria, recipient nations fail to receive the potential benefit of U.S. investment in technical assistance. It is even doubtful that political objectives can be realized by technical assistance programming that disregards the fundamental importance of such criteria. Certainly, the experience with the wheat project in Bolivia suggests that reliance on the subjective system of programming has imposed relative losses on that society. Furthermore, there is no evidence that U.S. political objectives were met by ignoring the economic criteria.

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An Approach to Specifying and Estimating Nonreversible Functions

James P. Houck

This note concerns the specification and estimation of nonreversible linear functions in economic research. Commonly suggested applications involve short- or long-run supply curves that, because of asset fixity or other rigidities, are more output responsive for price increases than for price decreases. The theoretical reasoning behind such functions is not at issue here, only the empirical testing of the nonreversibility hypothesis.

In 1971, Wolffram proposed an ingenious method of dealing with nonreversibilities through partitioning (or segmenting) the variables involved. Tweeten and Quance further discussed the idea but generally endorsed the Wolffram method. Interested readers are referred to those papers, since their essentials are not repeated. In what follows, a rather simple alternative approach for specifying linear nonreversibilities is suggested. This method is consistent with the Wolffram technique but is operationally clearer. In addition, some results applying this technique in two empirical supply studies are discussed briefly to provide insight into some of the issues likely to arise.

Specification

Since nonreversibilities are most commonly expressed in terms of asymmetrical changes from a previous position in time (or possibly space), identification of the starting point or initial observation is central to the analysis. Yet this first observation has no independent explanatory power, since the differential effects to be measured hinge on changes from the previous position, not its level. This key point was not emphasized by either Wolffram or Tweeten and Quance.

Imagine that the variable Y depends upon the values taken by X and that both are time-series variables. The hypothesis to be examined is that one-unit increases in X from period to period have a different absolute impact on Y than do one-unit decreases in X. Such a relationship can be written

$$\Delta Y_t = a_o + a_1 \Delta X_t' + a_2 \Delta X_t'' \tag{1}$$

for $i = 1, 2, \ldots, t$, where $\Delta Y_t = Y_t - Y_{t-1}$; $\Delta X_t' = X_t - X_{t-1}$ if $X_t > X_{t-1}$ and $= 0$ otherwise; $\Delta X''_t = X_t - X_{t-1}$ if $X_t < X_{t-1}$ and $= 0$ otherwise; X_o is the initial value of X; and Y_o is the initial value of Y.

Other variables, segmented or not, could be added to this basic specification, and a_o might be zero, positive, or negative. A nonreversibility occurs in ΔY if $a_1 \neq a_2$. To link equation (1) to the initial position, note that the value of Y at any point t is

$$Y_t = Y_o + \sum_{i=1}^{t} \Delta Y_i, \tag{2}$$

for $i = 1, 2, \ldots, t, t+1, \ldots, T$, where T is the total number of observations beyond the initial value. The difference between the current and the initial value of Y is the sum of the period-to-period changes that have occurred. So,

$$Y_t - Y_o = \sum_{i=1}^{t} \Delta Y_i. \tag{3}$$

Inserting equation (1) into equation (3) and simplifying,

$$Y_t - Y_o = a_o t + a_1(\Sigma \Delta X_t') + a_2(\Sigma \Delta X_t''). \tag{4}$$

Letting Y_t^*, R_t^*, and D_t^* equal $Y_t - Y_o$, $\Sigma \Delta X_t'$, and $\Sigma \Delta X_t''$, respectively,

$$Y_t^* = a_o t + a_1 R_t^* + a_2 D_t^*, \tag{5}$$

where R_t^* is the sum of all period-to-period increases in X from its initial value up to period t, and D_t^* is the similar sum of all period-to-period decreases in X. The variable R^* is always positive, and D^* is always negative. If a_o is not zero, it appears in equation (5) as a trend coefficient. If any other variables affect ΔY in equation (1), they also would be entered in equation (5) as deviations from their initial values.

The computation of R^* and D^* for a hypothetical set of ten observations on a variable X are illustrated in table 1. The hypothetical data are the same as used by Wolffram. Interested readers will note that both methods of segmenting the variable X are basically comparable. However, the method proposed here flows directly from considering period-to-period changes and does not require, as does the Wolffram method, an implicit change in the sign of the a_2 coefficient in order to compare it with a_1. If a positive (negative) net relation exists between Y and X, both a_1 and a_2 are positive (negative) in the formulation proposed here using R^* and D^*. In addition, expressing all variables as deviations from

James P. Houck is a professor in the Department of Agricultural and Applied Economics, University of Minnesota.

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Table 1. Hypothetical Example of Segmented Variable X_t

Variable (X_t)	X'	X''	R^*	D^*
$X_0 = 10$	—	—	—	—
$X_1 = 13$	3	0	3	0
$X_2 = 11$	0	−2	3	−2
$X_3 = 14$	3	0	6	−2
$X_4 = 17$	3	0	9	−2
$X_5 = 12$	0	−5	9	−7
$X_6 = 9$	0	−3	9	−10
$X_7 = 16$	7	0	16	−10
$X_8 = 20$	4	0	20	−10
$X_9 = 18$	0	−2	20	−12

initial values eliminates the problem of how to deal with the equation intercept, a question of some complexity when actual values of the variables are employed (Wolffram, Tweeten and Quance).

Thus, equation (5) is a simple estimating function for a nonreversibility to which other variables and stochastic properties can be added. Of special interest would be the test for $a_1 = a_2$ to confirm or refute the hypothesis of nonreversibility. By extension, other functional forms that can be linearized for estimation (such as logarithmic, semilogarithmic, etc.) also can be adapted to nonreversibility analysis using this basic framework and this technique of partitioning variables.

Empirical Applications

The hypothesis of nonreversibility in supply response to price change was tested using previously estimated supply equations for two quite different U.S. farm commodities: milk and pinto beans. Only those results that pertain to the nonreversibility question are discussed. A complete presentation of the two supply studies would far exceed the objectives of this note.

A fully reversible milk supply function was estimated by OLS using annual data from the 1947–72 period. The estimated function displays significant (5.0% level or stronger) coefficients with expected signs on lagged milk prices received by farmers, cattle prices, hog prices, average farm real estate prices, percentage unemployment, percentage of total dairy cows bred artificially, and lagged milk output (Hammond). The value of $\bar{R}^2$ is 0.94. The estimated coefficient on lagged milk price has a t-value of 5.96. At the point of means, the price elasticity of supply is 0.23, a result that compares favorably with the elasticities generated under alternative specifications of this basic equation and with other work on milk supply.

When the data are transformed into deviations from initial (1947) values, and the lagged milk price is segmented into rising and declining phases, two significantly different price elasticities emerge. Moreover, the estimated coefficients and standard errors of the other explanatory variables change very little, and the $\bar{R}^2$ increases to 0.96, as is expected.

The price elasticity for price increases is highly significant at 0.25. The elasticity for price decreases also is highly significant but is 0.18. The statistical test for the difference between the coefficients (Johnston, pp. 155–56) permits rejection of the null hypotheses at beyond the 5% level. These results support the hypothesis of a short-run nonreversibility in milk supply response. Such a phenomenon has long been suggested by dairymen.

The second example involves a relatively minor annual crop: pinto beans. Various quantity supply functions for this crop were estimated for other purposes (Ryan). Using 1953–75 data, these OLS supply functions employ explanatory variables such as lagged pinto bean prices received by farmers, lagged sugar beet prices, weather proxies, and a measure of price instability for the previous three years. Reversible equations with various combinations and forms of these variables display R^2 values from 0.90 to 0.94. Individual regression coefficients are significant at beyond the 5% level, and expected signs emerge on all variables. The one-year lagged price response has t-values of 5.79 to 7.41, depending on the particular specification used. At the point of means, the estimated price elasticity is between 0.99 and 1.02.

As with the milk supply analysis, the data are transformed into deviations from initial values (1953), and the lagged pinto bean price is segmented. In none of the various specifications did statistically significant evidence of nonreversibility emerge. The estimated coefficients are very similar to one another for either rising or falling prices, and both have t-values between 4.0 and 6.0. The estimated price elasticities at the means are very close to 1.0 for both rising and falling prices. Moreover, the segmentation does not appreciably alter estimated coefficients on the other variables.

While certainly not conclusive, these two illustrations suggest that hypothesis of nonreversibility is tenable in agricultural supply work. Even in cases where the hypothesis is not supported, the results for other explanatory variables may not be substantially altered when data are segmented and transformed to explore nonreversibility.

In using the techniques suggested here, the investigator should remain aware of a few problems that might emerge. First, the segmentation and data transformation consume two degrees of freedom: one for the added price variable and one for the loss of explanatory power in the initial observation. Second, intercorrelations among explanatory variables might be intensified. When a variable is segmented into increasing and decreasing components, it is possible that the two segments will be highly correlated with each other or with other trend-like variables in the analysis. On the other hand, if the variable to be segmented (a price, for example) is

already highly correlated with other variables (other prices, for example), then segmentation may well reduce the intercorrelation problem. It is impossible to say in advance which tendency, if either, will prevail.

In both the milk and pinto bean supply studies, some intercorrelations were increased between the price segments and other variables as compared with those using actual prices. But because of the high overall $\bar{R}^2$'s, no real estimation problems emerged. Similarly, no estimation problems occurred in these two examples because of strong correlation between the two segments; the correlation coefficients r were -0.78 and -0.87 between the segments of milk and pinto bean prices, respectively. The segmentation process did not alleviate any high intercorrelations between the actual prices and other variables, since none were present initially. On balance, each of these commodities provided a favorable environment for an empirical test of nonreversibility in supply response. Other investigations surely might be less fortunate.

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Computer Graphics: An Educational Tool in Production Economics

David L. Debertin, Angelos Pagoulatos and Garnett L. Bradford

Students usually have difficulty in understanding the nature of surfaces generated by two-input production functions. Isoquant maps in two dimensions are easy to draw, and wooden or plastic models have sometimes been used by instructors to help students discover the relationship between an isoquant map and the resultant production surface. However, these models are difficult to build and expensive. Moreover, the exact mathematical specification of the production function underlying the plastic or wooden model is usually ambiguous. But the most serious disadvantage of such a model is that even if a mathematical specification of the production function underlying the model is known, it is impossible with a single model for the instructor to change the underlying function (and hence the isoquant map) so that the student might observe the resulting impacts on the surface of the function.

Computer graphics can be used as an educational tool for helping students better learn production economics concepts. A plotter linked to a computer is used to generate three-dimensional illustrations of two-input agricultural production functions.[1] Moreover, production economics problems often require the maximization or minimization of a function, and computer graphics can be used to develop an understanding of the mathematical conditions necessary and sufficient for a maximum or minimum. This use is particularly important to supplement material in beginning graduate level production economics classes.

Surfaces of Production Functions

Beginning graduate students can usually discern the isoquant map generated by most two-input production functions from the mathematical specification of a production function and draw the map. What is difficult for students to perceive is the importance of the underlying isoquant pattern in determining the shape of the agricultural production function surface.

The Cobb-Douglas is frequently the first production function presented to students in mathematical form. A Cobb-Douglas as represented by[2]

$$y = Ax_1^{\alpha}x_2^{\beta} \tag{1}$$

generates isoquants that are asymptotic to the x_1 and x_2 axes. If $\alpha < 1$, $\beta < 1$, and $\alpha + \beta = 1$, diminishing marginal returns to x_1 and x_2 and constant returns to scale exist. The illustration generated by equation (1) when $\alpha = 0.4$ and $\beta = 0.6$ shows students the exact nature of the surface of the Cobb-Douglas function (figure 1). Computer graphics reveal the shape of the production surface with diminishing marginal returns to x_1 and x_2 and constant returns to scale. With the aid of the computer, students can easily and quickly compare surfaces generated under the alternative assumptions with respect to the parameter values.

The transcendental production function was popularized by Halter, Carter, and Hocking in the 1950s. It became popular since appropriate selection of parameters yields a single function representing the three stages of production comparable with the illustrations contained in undergraduate microeconomics texts. The isoquant map generated by the transcendental

$$y = Ax_1^{\alpha_1}x_2^{\alpha_2}e^{(\gamma_1 x_1 + \gamma_2 x_2)}, \tag{2}$$

when $\alpha_1 = \alpha_2 = 4$, $\gamma_1 = \gamma_2 = -2$, and $A = 1$, consists of a series of concentric rings centered at the global maximum for the function. Ridge lines dividing the stages of production are parallel to the x_1 and x_2 axes and form right angles at the maximum of the function.[3] Figure 2 provides students with an illustration of the production surface resulting from equation (2). The three stages of production are clearly visible. No output is produced if either x_1 or x_2 assumes a value of zero, suggesting that for the transcendental function isoquant rings do not intersect but rather become tangent to the input axes.

All Cobb-Douglas production functions have

David L. Debertin is an associate professor, Angelos Pagoulatos is an assistant professor, and Garnett L. Bradford is a professor in the Department of Agricultural Economics, University of Kentucky.

This paper is an overview of work reported in a research report by the authors. Computer-generated illustrations used in this paper were selected in order to provide evidence of the range of possible uses of computer graphics to supplement production economics courses. Herman E. Collins wrote the PL-1 plotter program.

[1] A copy of the PL-1 plotter program is available in the research report (Debertin, Pagoulatos, and Bradford). Program users select the function to be plotted, function parameters, and values over which the function is to be plotted.

[2] Throughout this article y is used to designate an output, x_1 and x_2 are two inputs or factors of production, e refers to the base of the natural logarithm, A and α, β, γ, and ρ designate production function parameters.

[3] The function $y = Ax_1^{\alpha_1}x_2^{\alpha_2}e^{(\gamma_1 x_1 + \gamma_2 x_2 + \rho_1 x_1 x_2)}$ will generate ridge lines that are not parallel to the axes.

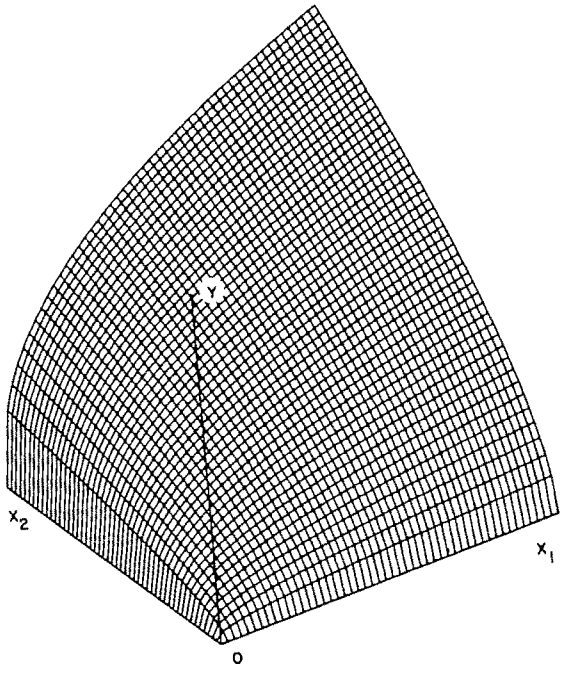


Figure 1. The Cobb-Douglas: $y = x_1^{0.4}x_2^{0.6}$

elasticities of substitution equal to one. The constant elasticity of substitution (CES) function (Arrow et al.) allows for constant elasticities of substitution other than one. The general form of the CES is

$$y = A[\alpha x_1^{-\rho} + (1 - \alpha)x_2^{-\rho}]^{-\frac{1}{\rho}}. \tag{3}$$

The CES can be a valuable pedagogical tool because the single function can be used to generate a wide variety of different isoquant patterns. The elasticity of substitution (σ) is related to the parameter ρ by the identity

$$\sigma = \frac{1}{1 + \rho}; \tag{4}$$

and it is the value of σ (and hence ρ) that determines the shape of the isoquants generated by the CES. Henderson and Quandt outline five cases with alternative assumptions with respect to the value of σ. If $\sigma = 1$, the function becomes the Cobb-Douglas (figure 1). The surface of the CES when $0 < \sigma < 1$ is virtually indistinguishable from the Cobb-Douglas. When $\sigma \to \infty$, the isoquants become diagonal lines of constant slope intersecting the x_1 and x_2 axes. When $\sigma \to 0$, isoquants approach right angles. The resultant surface becomes pyramidal as ρ becomes very large. When $\sigma < 1$ and $-1 < \rho < 0$, isoquants cut both axes. Figure 3 illustrates the surface when $\rho = -0.5$. The surface is similar to the Cobb-Douglas (figure 1), except that because isoquants intersect both axes it is possible to produce a positive output (y) even when one of the inputs is not present. This is clearly evident to students who carefully examine figure 3.

Sufficient Conditions

The problems faced by students who are attempting to understand the meaning of sufficient or second-order conditions required for the maximization of a function are very similar to those faced by students confronted for the first time with the mathematical form of a production function. (See the discussion on sufficient conditions in Chaing and in Intrilligater.) In both cases, a three-dimensional graph is a useful supplement to the mathematical presentation.

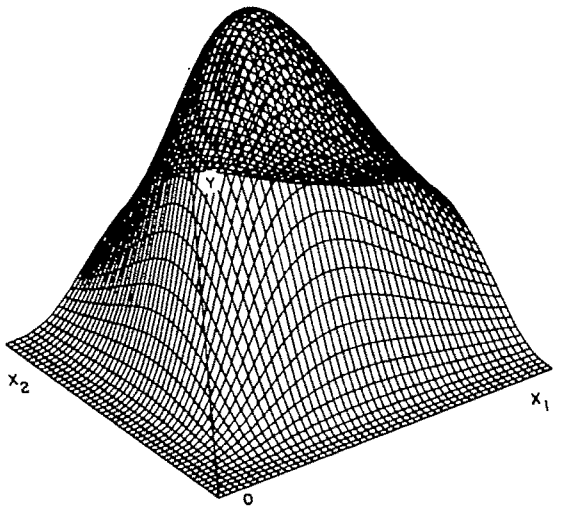


Figure 2. The transcendental: $y = x_1^4x_2^4e^{(-2x_1-2x_2)}$

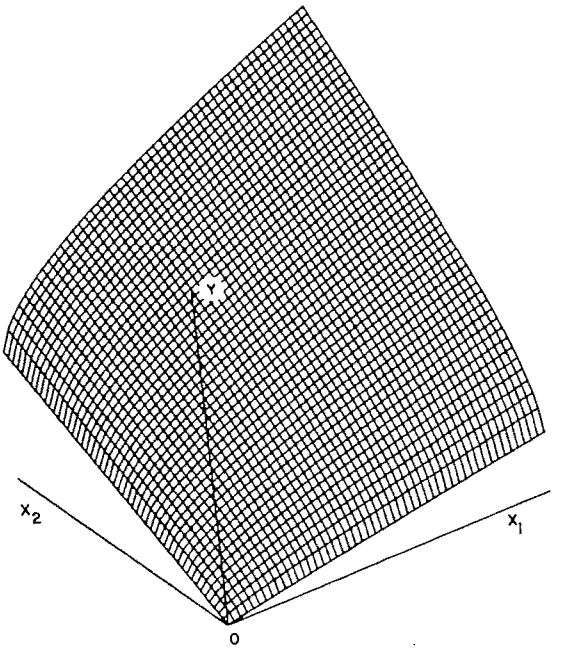


Figure 3. The CES: $y = (0.4x_1^{0.5} + 0.6x_2^{0.5})^{1/0.5}$

For example, a computer-generated graph might be used to illustrate a maximum with an equation such as

$$y = -x_1^2 - x_2^2, \tag{5}$$

or a saddle point with an equation such as

$$y = x_1^2 - x_2^2. \tag{6}$$

The usefulness of computer graphics as a tool for helping beginning graduate students learn about second-order conditions is perhaps best illustrated with the function

$$y = 40x_1 - 12x_1^2 + 1.2x_1^3 - 0.035x_1^4 + 40x_2 - 12x_2^2 + 1.2x_2^3 - 0.035x_2^4. \tag{7}$$

Equation (7) generates nine extreme values (four maxima, one minimum, and four saddle points), occurring over the plotted range (figure 4). Relevant second-order conditions are summarized in table 1. A careful scrutiny of figure 4 reveals the nine extreme values.

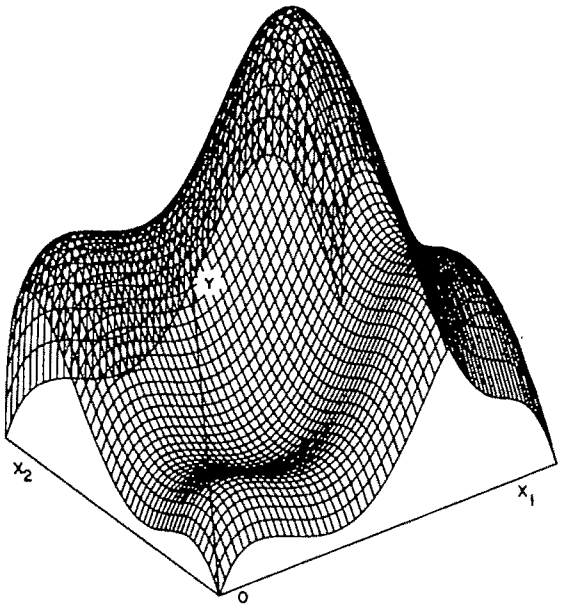


Figure 4. Local and global optima: $y = 40x_1 - 12x_1^2 + 1.2x_1^3 - 0.035x_1^4 + 40x_2 - 12x_2^2 + 1.2x_2^3 - 0.035x_2^4$

Application to Instruction

Computer graphics has been used as an instructional aid in a graduate production economics course that includes a discussion of alternative algebraic forms for production functions. Students are first asked to use mathematics to compare functions such as the Cobb-Douglas, the transcendental, the CES, and the Spillman with respect to characteristics such as the shape of isoquants, the location and shape of ridge lines, and the elasticity of substitution. Each student is then provided with

Table 1. Second-Order Conditions for Figure 4

Value of x_2	Value of x_1: 2.5366	6.9342	16.2434
	Local Maximum	Saddle Point	Global Maximum
16.2434	$y = 232.3$ $\|H_1\| < 0$[a] $\|H_2\| > 0$	$y = 209.5$ $\|H_1\| > 0$ $\|H_2\| < 0$	$y = 379.8$ $\|H_1\| < 0$ $\|H_2\| > 0$
	Saddle Point	Local Minimum	Saddle Point
6.9342	$y = 61.9$ $\|H_1\| < 0$ $\|H_2\| < 0$	$y = 39.1$ $\|H_1\| > 0$ $\|H_2\| > 0$	$y = 209.5$ $\|H_1\| < 0$ $\|H_2\| < 0$
	Local Maximum	Saddle Point	Local Maximum
2.5366	$y = 84.8$ $\|H_1\| < 0$ $\|H_2\| > 0$	$y = 61.9$ $\|H_1\| > 0$ $\|H_2\| < 0$	$y = 232.3$ $\|H_1\| < 0$ $\|H_2\| > 0$

[a] $|H_1| = \left|\frac{\partial^2 y}{\partial x_1^2}\right|$. $|H_2| = \begin{vmatrix} \frac{\partial^2 y}{\partial x_1^2} & \frac{\partial^2 y}{\partial x_1 \partial x_2} \\ \frac{\partial^2 y}{\partial x_2 \partial x_1} & \frac{\partial^2 y}{\partial x_2^2} \end{vmatrix}$

a copy of the twenty-six computer-generated illustrations contained in Debertin et al. Students are asked to determine if the illustrations of production surfaces are consistent with the characteristics of the function that were derived mathematically. Students are then allowed to run the computer graphics program on their own, varying parameters of traditional production functions, and examining properties of functions they develop on their own.

Computer graphics has been particularly useful in supplementing the terse mathematical presentation of the CES contained in Henderson and Quandt. With illustrations of the five CES cases in Henderson and Quandt, students in the class for the first time were able to visualize the interrelationships that exist between the elasticity of substitution, the shape of the isoquant, and the appearance of the resultant production function surface.

Computer graphics has been equally important in supplementing presentations dealing with the mathematics of sufficient conditions. First, the rules with regard to signs on principal minors of Hessians sufficient for maxima or minima are presented by the instructor. Students are asked to determine if each extreme value of equation (7) is a maximum, a minimum, or a saddle point. Students then examine figure 4 to verify the conclusions they reached mathematically. Finally, students are asked to develop a function of their own, find the critical values, and verify the second-order conditions by running the computer graphics program.

Computer graphics enables the student to develop an understanding of the relationship between a two-dimensional drawing of an isoquant map and the resultant production surface. Moreover, with computer graphics it is possible for the student to generate three-dimensional illustrations of surfaces for a host of production functions, not just the usual textbook case. Parameters of the production function can be varied and the resultant impact on the surface be scrutinized by the student. Students can compare surfaces among production functions widely used in agricultural economics research. Students and instructors both discover that even minor changes in the specification of a function and its parameters can have a major impact on the appearance of the computer-generated illustration. Shapes of agricultural production function surfaces can be discerned at least as easily from a computer-generated illustration as from a wood or plastic model, and yet copies of the illustrations can be carried by students in a notebook.

Computer graphics, when used as a tool to supplement instruction dealing with optimization problems, provides students with vivid illustrations of the meaning of mathematical conditions necessary and sufficient for a maximum or minimum. Students can easily grasp the importance of sufficient conditions when a mathematical presentation is supplemented with computer-generated illustrations.

Computer graphics is quite inexpensive and simple for students and instructors use. The only equipment required is a computer linked to a CALCOMP (or other) plotter, which is available at nearly all university computing centers. The computer program developed at Kentucky for using the CALCOMP plotter is simple enough to operate so that students may run their own graphics programs. The cost of each illustration is approximately $1.50 on an IBM 370/165 system. Students in small graduate classes may each run the program several times, and the cost is not excessive. The cost might be excessive if each student in a large undergraduate class were to run the program.

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than another and ignore the man of no other property who went hungry when his common law claim on water was denied. They ignore the fisherman or the boater or the saw log floater who lost out with appropriation. In the Anderson and Hill formulation, there are no moral issues; all is a matter of the highest bidder—who can spend the most for law change. In this conception, government is a neutral respondent to market forces that are implied to be a function of technology, resource availability, and consumer taste. They ignore government as a determinant of who has to buy out whom and who has anything with which to make a bid in the first place. In other words, they selectively ignore the existence of some institutions while performing a partial analysis of another. These other institutions are *what influence* marginal costs and benefits to changing a particular property rule.

Anderson and Hill give us a picture of a relatively passive and neutral government as the key to economic growth. After establishing exclusive and transferable private rights, there is no useful or legitimate role for further collective action except for the troublesome equity issue. The following quote embodies one of the most persistent and widespread myths of the American mind. After noting the role of government in eminent domain, police power, and taxation, they say, "Nonetheless, by the time of the Revolution the landowner had basically acquired the right to use his land as he saw fit with few restrictions and controls by the government" (p. 939). This is selective perception guided by a theory with little probative value. The authors begrudgingly notice farmer interest in tariff policy, but they ignore the government's role in roads and canals, the credit and banking system, reclamation and drainage, the development of tort and contract law, and later the interpretations of the commerce clause of the constitution. (Reading Anderson and Hill, one would never guess that the Supreme Court existed or had any creative role.) They ignore such dominant collective actions as supply and price controls for tobacco in the 1630s (Edwards, p. 184). Acting individually, it was in everyone's interest to plant all they could, but a glut developed and farmers used government to establish a price that all enjoyed collectively. Private ownership of land did not protect exchange values, and farmers did not wait until the Great Depression and Roosevelt to develop collective action.

Land use controls did not wait until the modern environmental movement. Building setbacks and roof style were sharply controlled in colonial New England towns. Government was also active in promoting new agricultural crops. England did not like to be dependent on Italy for silk, so the Virginia Assembly in 1619 ordered each man to plant six mulberry trees annually for seven years. In 1740, membership in the Georgia Assembly was made conditional on the planting of 100 mulberry trees (Edwards, p. 187). The role of private property and the later public lands disposal is not to be denied, but neither can other varied expressions of collective action in shaping what opportunities were profitable. These actions did not cease in 1776 and start again in 1875.

Why must Anderson and Hill insist that up until 1875 private rights in inputs were the dominant productive force while ignoring other collective action? It is because this view of history is necessary to the credibility of their theory. As Bartlett explains, once it is acknowledged that resources can be used to produce income via rights change as well as via goods production, there are real questions as to the legitimacy of any market derived income distribution. Anderson and Hill try to solve this problem by distinguishing efficiency and transfers. It is claimed that some resources used to change rules create efficiency and more output, while others are a wasteful use of resources to alter rules that only result in income transfers. By this concept, they assert that the move to the western appropriations doctrine was efficient, but tariffs, regulation of railroads, co-op marketing, and New Deal price-support programs were just transfers. These transfers are seen to serve equity and are rather begrudgingly accepted. These after all may have to be accepted to forestall another revolution, but we were invited in the bicentennial year to be sure to remember that these rights were not what made America great—that accolade is reserved for the efficient destruction of communal property and establishment of the appropriation doctrine, etc. Once exclusive and transferable rights are established, any further use of resources to change the rules is somewhat wasteful, even if some is tolerated in the name of equity.

The role of private property in motivating effort is not to be ignored. However, it would surely be a mistake to regard it as the only way. Ciriacy-Wantrup and Bishop demonstrate that many of the world's communal lands were well managed and preserved and did not suffer what is now mistakenly assumed to be the inevitable "tragedy of the commons." While there are some Pareto-better rule changes, it must not be forgotten that being declared owner of water (and requiring fishermen to make a bid rather than to receive an offer) is no different than having the right to collective bargaining via co-ops, enjoying a tariff, or any of the other things that Anderson and Hill regard as mere transfers. When interests conflict, the government by action or inaction decides whose interests count. The issue is not government or no government, but how government will be used.

What about the Anderson and Hill claim to explain resource allocation? They never address this question is any substantive way. They use theory to argue that exclusivity and transferability are by definition efficient. If the country grew, it must have been due to these rights. There is no need to systematically relate differences in rights to who gets what. There is never a glance at the problem of poverty or backward regions. Even on the example

The Role of Private Property in the History of American Agriculture, 1776–1976: Comment

A. Allan Schmid

After years of relative neglect, there is a growing literature on the economics of property rights. A recent example is provided by Anderson and Hill. They nominally address two questions: how to explain the evolution of particular varieties of property rights, and how these changing rights have affected resource allocation. There is really a third implicit purpose, and that is to justify a particular set of rights. I shall argue that their answer to how rights evolve is severely incomplete, that they never really answer how rules affect the substance of resource allocation, and that their justification of so-called "private property" while pretending to be scientific is value presumptive.

Why do rights change? Anderson and Hill argue that institutions are subject to a productive process like any other commodity. "Efforts to change the rules can be thought of as input into the production of an institutional structure" (p. 938). Seen in this light, changes in rights are a matter of establishing a new equilibrium to marginal benefits and costs of productive efforts devoted to rule change in reaction to changes in relative factor prices.

Anderson and Hill use their theory to explain why people seek property: they seek it when it becomes valuable and scarce. The fact that nobody needs property when there is no interdependence is hardly a new insight. Anderson and Hill go on to use their theory to explain why certain varieties of rights are sought. For example, why did early colonial attempts at a communal agriculture fail? Because some people shirked, say Anderson and Hill. Those that worked found it profitable to spend the effort to change the rules. It is not clear in the paper why the shirkers did not find it equally profitable to retain the old rules. Neither is it clear what happened to the shirkers. Perhaps it is presumed that they reformed themselves. Perhaps there were no sick or lame in the colonies.

What explains the asserted fact that communal property disappeared faster in New England than in the Chesapeake Bay Region? Differences in the supply of shirkers? Wrong. It was due to the relative scarcity of land, say Anderson and Hill. Supposedly where land was better and more plentiful in the Chesapeake, there was less congestion, and it paid no one to work to define new rights. The logic is hard to follow here. If the Chesapeake region began with communal tenure, the availability of land does not solve the shirker problem unless all shirkers can be left behind and a new commune of like-minded workers established.

The Anderson and Hill theory suggests no other possible source of rights change, so it never occurs to them to look for other possible explanations. As an aside, they do note that ideology is a factor. Yet, this does not fit their theory very well, and it is not integrated into it. Could it be that New England and Chesapeake people had different ideologies? Anderson and Hill do not inquire. Neither do they inquire into the interaction of property in civil rights in relation to property in land. Could it be that the rules of popular access to government differed in the two regions? Harris notes differences between the three corporate colonies of Massachusetts, Connecticut, and Rhode Island and the others. "Differences were associated with the religious ideas of the first settlers, their extensive chartered privileges, their corporate form of organization, and the haphazard and uncontrolled pattern of colony location" (p. 98). He further notes that "It would be difficult to overstress the importance of the influence of local autonomy in Massachusetts upon later events" (p. 106). On the other hand, Maryland was a proprietary colony founded by Lord Baltimore with extensive powers that the king did not even have in England. There was no Mayflower Compact formulated by the Maryland settlers. I suspect that we need to look at differences in people and their political institutions, not just differences in land or prices of farm commodities.

The fact that people use economic resources to change institutions is undeniable. To argue that it is the only or the prime factor in change is incredible (and no evidence is offered by Anderson and Hill).

Anderson and Hill next apply their model to water rights. In regions where water was plentiful, there were riparian rights; where scarce, the appropriation doctrine emerged. Unquestionably, the appropriation doctrine does affect investment in consumptive uses of water. But they would have us believe that some rights emerge from a void and create efficiencies implying everyone wins in the new productivity. If resources are scarce, any right is an expansion of opportunity for some and a contraction for others. We are not told what happened to the western riparian who lost out under appropriation. We are only told that water moved to its most efficient use. This begs the issue of what interests become a cost to be considered. Anderson and Hill presume that one person is more worthy

A. Allan Schmid is a professor in the Department of Agricultural Economics, Michigan State University.

Educational Television as an Extension Delivery System for Teaching Futures Market Concepts

Larry D. Jones, D. Milton Shuffett, Steve Callahan, John C. Gamble, and Charles L. Moore

Television as a medium for delivering extension information has the potential of providing information to more individuals in a single program than most extension personnel reach in one year. Yet, television has been little used as an information delivery system for educating farmers concerning agricultural economics problems. The high cost of commercial air time has meant that few stations are willing to supply time for educational programming on a regular basis. Even if air time is available, it often cannot be obtained at an optimal viewing time. Communicating information via television requires special skills different than those used by extension personnel in a traditional public meeting educational setting. Most extension economists are not as effective in front of a television camera as are professional television commentators.

The purpose of this paper is to explain how educational television is used to teach commodity futures market concepts. The futures market program was designed to educate farmers and other interested persons in the basics of forward pricing and to help them apply that information to their own business situations. Television offers the most direct and cost-effective link with those farmers most in need of information. It is one medium that brings that information to those interested on a regular basis.

Our approach in the use of television as a means to educate farmers is unique in that the educational effort consists of not merely a single show but of thirteen regular, weekly programs on agricultural marketing. The program was aired during prime-time evening television beginning in February 1976.

Educational television stations rather than commercial stations were used because of the availability of air time. The educational television system in Kentucky is one of the largest and most complete in the nation, consisting of fourteen ultrahigh-frequency stations across the state. This is a particular advantage, compared with local, private television stations that can cover only part of the state.

Larry D. Jones and John C. Gamble are associate extension professors, D. Milton Shuffett is a professor, Steve Callahan is an extension specialist, and Charles L. Moore is an assistant extension professor in agricultural economics at the University of Kentucky.

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The idea of a marketing program did not evolve solely out of the Department of Agricultural Economics. Rather, members of the agricultural leadership in the state expressed to Kentucky Educational Television (KET) their desire that KET bid on a weekly farm business series. A committee composed primarily of agricultural economists was asked to prepare a program proposal that Educational Television could consider for implementation.

The origination of this program indicates a key factor one must consider in making this type of venture. Agricultural economists acting alone may not convince television producers of the need for a regular show on agricultural marketing or other agriculturally related topics. Our experience suggests that the demand for this kind of educational effort must come from the agricultural leadership in the state.

Why Television?

We sought to educate a large number of farmers about futures market concepts. We faced the following constraints: (*a*) a small extension marketing staff, (*b*) a large geographical area in which to reach farmers, and (*c*) limited travel funds.

Educational television has four unique qualities making it applicable to our objectives and constraints. Television is immediate. Farmers need not wait for an agricultural economist to be available to teach them about marketing and forward pricing.

Television is flexible. The program host transcends the limitations of the classroom or seminar, and through film clips, animation, and live interviews (to name a few examples) presents information in a manner best suited to the nature of that information and most appealing to the farm audience.

In our state, educational television reaches the entire state. The geographic isolation of many rural areas is no longer a barrier to self-improvement. Through television, farmers obtain information in the comfort and privacy of their homes, which they might otherwise have had to travel miles to obtain. Thus, information is obtained without interrupting their workday or losing needed rest time in transit.

Television is familiar. Television, available in the

privacy of the home, is especially appealing to the adult who is often reluctant to admit to educational deficiencies in a group situation. The television host speaks directly to the individual viewer and serves as an authority, with none of the negative connotations that adult learners may ascribe to authority figures.

Television as an extension delivery system also has limitations. First, viewer feedback is usually absent. Second, there are no easy means for handling questions. Third, the feeling of comradeship often found in a public meeting is not achieved. Methods are designed to circumvent and minimize these kinds of limitations.

Methods Employed

In our approach to using television as an extension delivery vehicle, the agricultural economist was used as a resource person. Agricultural economists determine the content and sequence of the subject matter, generate ideas, and develop brief topical outlines for each program. Hence, agricultural economists are responsible for the technical accuracy of the programs. A professional writer takes these ideas and prepares written scripts. Professional announcers are responsible for communicating ideas to the audience. Professional artists are employed to develop visuals.

An outline and sequence of subject matter is prepared several months prior to taping (table 1). Two review and question sessions are scheduled in addition to programs devoted to explaining futures market concepts and illustrations. Questions are submitted by telephone and by mail. These questions are answered on the air by agricultural economists through direct interviews. Submitted questions provide valuable viewer feedback.

The television writer receives written outlines and visual sketches three weeks prior to the taping date. The writer then prepares the script and sends the script back to the agricultural economist for review. The revised scripts are aired five days following taping.

Prepared scripts are read on camera using teleprompters. This delivery mode insures constant eye contact with the audience. Two communications specialists serve as program hosts. These professionals have agricultural training in addition to their communications skills. This approach insures that small talk is kept to a minimum and that the subject matter is covered in a professional manner.

Agricultural economists appear as interviewed guests for highlighting particular facets of the program. For example, an economist made a guest appearance to show how to construct a basis chart. An agricultural economist in another guest appearance showed how to determine an "asking price" when deciding whether to hedge. Commodity brokers and farmers who used the futures market also appeared as guests on the program.

Two months prior to the first program, promotion is begun to enroll farmers and others for the program. Farmers enroll through local county extension staff. Agents are furnished posters and enrollment forms to place in agribusiness establishments. News releases and radio tapes are also used to advertise the program. Enrollees receive by mail special materials (workbook) that complement the television tapes (Callahan, Gamble, and Shuffett). A mailing list is thus provided for use in program evaluation.

Table 1. Program Titles and Sequence of Subject Matter for "Farm Marketplace"

Program	Working Title
1.	Introduction to the various methods of marketing commodities
2.	An introduction to futures marketing
3.	What is basis?
4.	Working with basis
5.	Engaging in futures trading
6.	Review, and questions and answers
7.	Hedging
8.	Brokers and speculators
9.	Using the futures market—grain
10.	Using the futures market—livestock
11.	Using futures in feed
12.	April intentions report
13.	Review, and questions and answers

Evaluation

One week prior to the last program, a postcard questionnaire was mailed to the 5,000 participants who preenrolled through local extension staff. Enrollees were asked to indicate the number of programs watched as well as their general impression of the series. Five percent of those enrolled returned the questionnaires.

Thirty-six percent of the respondents had watched nine or more programs, while an additional 17% had viewed between six and eight programs. Twenty-seven percent had viewed three to five programs, and the remaining 20% had watched fewer than three. Ninety-three percent of the respondents indicated that they felt the series had helped them to understand better the farm marketing system. In addition, 28% indicated that they would use one of the strategies discussed on the program, while 9% said that they might possibly use one of the marketing strategies presented.

Enrollees were asked to indicate whether the television subject matter was clear and easy to understand. Seventy-eight percent of those responding said that the subject matter was clear and easily understood. The remaining 22% indicated that the subject matter was not easily understood. Seventy

percent of the respondents indicated that they would like to view the same program at a later date.

Our experience with television as a tool for delivering extension information suggests the following conclusions.

A professional script writer adds much to the program. Writing style for television is quite unique. This style is different from the methods that extension personnel usually employ. Most script writers find it easier to write a script from a brief outline rather than revising a script prepared by the agricultural economist. In addition, the economist can save valuable time if only an outline has to be initially prepared.

Numerous visuals are essential for television communication. Verbal dialogue without visuals becomes boring to a television audience. Hundreds of visuals are required for a thirteen-week program, and good visuals are difficult to prepare. For these reasons, professional artists are essential to programs of this size.

Communications specialists are better trained to host a regular program series than most agricultural economists. It is helpful if the communicators also have agricultural training.

Viewer feedback after two programs revealed that the material moved at too rapid a pace. One reason cited is the lack of commercials on educational television. Our taping experience suggests that liberal use of visuals, having guest interviews, and film clips makes it easier to follow educational programs on television.

Written materials that complement the television tapes are essential. Ideally, a complete workbook should be distributed to all enrollees prior to the first show. The complementary materials should be liberally referenced on the air as the program progresses.

Large amounts of staff time are required from the agricultural economist. Each program required at least 30 man-hours from the agricultural economist. Agricultural economics departments must be willing to devote many man-hours to similar ventures.

Coordinating such a venture is cumbersome. Scripts have to be prepared, visuals designed, special materials prepared, tapings scheduled, and guests chosen and scheduled. Clearly, an adequate amount of lead time is required to produce a show of this magnitude. We allowed two months of lead time for each show. Four to six months would have been more desirable.

Television facilities and support are essential to ventures such as the program to teach farmers about futures markets. Our state is fortunate in that extensive, modern facilities are available. KET broadcasts in color, has modern equipment, and covers the entire state. In addition, the facilities are less than two blocks from the Department of Agricultural Economics. Clearly, such ventures are impossible unless both the manpower and facility commitment from educational television are available.

Producing a 30-minute program for thirteen consecutive weeks is expensive. KET provided a producer, director, production assistant, script writer, two artists, a facility, camera crews, taping equipment, tapes, and a $2,500 set specially prepared for the program. Educational Television estimates that their total cost in man-hours and facilities came to approximately $52,000, or $4,000 per program. While producing a program of this magnitude is expensive in hours and actual expense, the money expended is small compared with the cost of running a conventional extension program in our state.

Given our state's travel and subsistence budgets, we estimated that a conventional extension program for reaching 5,000 participants would have required three man-years of work at a cost of approximately $120,000. This reported case demonstrates primarily how budgetary constraints may be overcome by shifting the cost burden for an extension educational program to some external agency, in this case the educational television system.

One advantage offered by television ventures is that the tapes are available for subsequent use. Our futures market tapes, for example, were rerun on KET in early 1977. In addition, the video tapes are now available for local meetings.

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Callahan, Steve, John C. Gamble, and D. Milton Shuffett. *Farm Marketplace Workbook*. Dep. Agr. Econ. University of Kentucky, Jan. 1977.



A Pilot University-Industry Master's Training Program

Gary T. Devino

In a December 1976 open letter to members of the American Agricultural Economics Association (AAEA), the Industry Advisory Committee of the AAEA stated: "In the experience of industry employers, today's graduate student in agricultural economics is well trained in research techniques, but often lacks training needed to relate and communicate the results in the decision-making process" (p. 1). Business games, cases, and other methods may help prepare students for business careers but are not as effective as programs in which the student spends time in a business environment. Many agricultural economics departments have operated trainee programs for undergraduates. The role they can serve in students' programs and the benefits to the parties involved have been documented (Snodgrass). Few similar programs have been operated at the graduate level. Yet the benefits would appear to be at least as great for graduate students as for undergraduates.

To test the applicability of the concept, a pilot master's program has been operated for the last two years by the University of Missouri and Farmland Industries. The objectives of the program are different for Farmland and for the University. Farmland's reasons for becoming involved with the program include "The difficulty in finding college people with an interest or training that would lead to work with cooperatives" and "To get a qualified person to study specific co-op problems and suggest possible solutions" (Farmland Industries 1977, p. 11). The University's objectives are to provide an opportunity for students with a career interest in agribusiness to gain experience in business operations, to improve working relations with industry firms with the University benefiting through identification of curriculum changes needed for better preparation of students for careers in agribusiness, and identification of research proposals that are relevant to industry problems. This note describes and appraises the program.

Student Selection and Program Organization

Student applications for this program are accepted from throughout the Farmland operating area. All applicants are expected to have an undergraduate program that emphasized agribusiness management. Applicants are required to have completed sufficient economics, accounting, and other prerequisites to allow them to take first year master's of business administration work as well as graduate work in agricultural economics. Student selection is joint between the University and Farmland. The first screening is conducted at the University to assure that the applicants are academically qualified for a master's program. Applicants are not required to have a higher minimum grade point level than other students receiving assistantship offers. Farmland invites the several qualified applicants for an interview at its Kansas City Offices. The applicants are interviewed by individuals of both the personnel department and the management staff. Farmland then indicates to the University a suggested ranking of the applicants.

Master's programs in agricultural economics at the University of Missouri call for a minimum of twenty-four hours of coursework and six hours of research. Courses in intermediate price theory, intermediate income theory, and statistics are required. Students who are on an assistantship normally complete their program in seventeen to eighteen months. A student on the Farmland program meets the same minimum department requirements, but because of his or her interim on-location work with Farmland, the total program will usually extend to two years.

The first student on the program spent his first two semesters (summer and fall) on campus. Coursework for this period consisted of intermediate price theory, research methods, corporate capital markets, economics of marketing, advanced price analysis, financial management, and business and society. After spending three semesters (including summer term) on a Farmland assignment, the student finished his coursework by enrolling in two courses: theory of markets and current economic aspects of agriculture. He also completed his thesis. A second student is pursuing a comparable schedule.

Within the Farmland organization, students were assigned to Cooperative Finance Association, Farmland's finance subsidiary. When the first student entered the pilot program, Farmland personnel developed a detailed plan that outlined the type and duration of activities in which he would be engaged. The plan was reviewed and approved by the student's faculty adviser.

Upon shifting from the campus to Farmland, the

Gary T. Devino is an associate professor of agricultural economics, University of Missouri-Columbia.

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student was given a short orientation and then assigned to several projects. The projects were intended to be useful to Farmland. In addition, it was expected that papers developed from these projects would be acceptable to the University in lieu of a thesis. Topics were selected jointly by the student, his Farmland supervisor, and his academic adviser from a list of projects developed by the student and Farmland personnel. Progress on projects was monitored by both Farmland personnel and the student's academic adviser. This was accomplished by requiring reports from the student and by periodically meeting to discuss progress.

The first project was the development of a manual for conducting feasibility projects for investment in local cooperatives. The manual so developed was printed and used throughout the Farmland system (Farmland Industries 1976). In the second project, techniques and potential for leveraged leasing were analyzed. The paper that resulted from this project was used in-house at Farmland. The last project was an analysis of the financial conditions supportive of growth in local cooperatives. This project was used as the basis for a thesis (Mathis).

The time division between the University and Farmland appears to have been satisfactory, both in length and sequence. By spending his first two semesters at the University, the student was able to complete much of his coursework requirements. This added to his maturity and to the course background that he could apply to industry problems. The several months spent at Farmland or on Farmland assignment allowed the student time to become familiar with the organization, personnel, and problems with which he was dealing (table 1). By spending his last semester in campus, the student was able to complete his program in an academic environment. He also was able to interview for jobs without pressure from Farmland. Even though Farmland proved to be interested in employing the student, employment with the cooperative was not a condition for acceptance on the program.

Table 1. Allocation of the Student's Time with Farmland

Orientation—Farmland Industries	1 week
Orientation—Cooperative Finance Association	1 week
Travel with farmland personnel	
Management services fieldmen	1 week
Co-op development specialists	1 week
Business analysts	1 week
Identification and development of research	
Feasibility project manual	15 weeks
Leveraged leasing project	10 weeks
Financial growth in local cooperatives	20 weeks
Visits with other agricultural credit institutions	2 weeks

Program Evaluation

Because a trainee program extends the time required to complete a master's program, students may need more compensation than usually is provided. The first student on this program was paid $1,000 per year above the University of Missouri rate for half-time assistants. The level of compensation appears to be sufficient in that good applicants were attracted to the program both initially and at its renewal.

Organizing and supervising a joint industry-university program requires more faculty time than does a conventional master's program. Arrangements must be made for the student's supervision while on assignment. Time is required to communicate with the student and review his research while he is away from the university.

There are benefits to the university. Improvements in industry relations, research relevancy, and funds forwarded by the industry partner are useful to the university. In this program Farmland advanced funds for the student's salary and expenses. If a firm was interested in this type of program but could not fund it completely, other funding possibilities could include using regular assistantships as a base to which industry funds could be added.

Having the entire Farmland assignment in one block of time appears to be superior to alternating work semesters with academic semesters. The student's involvement in activities of the firm was deeper than probably would have been achieved during shorter time intervals. The student participated in a wide variety of headquarters' and field activities of Farmland. This exposure promoted an understanding of how business operates. It also helped generate project proposals that had the potential for direct benefit for Farmland. A final benefit to the student was the value potential employers placed on the training experience. Several attractive employment opportunities were available to the student at the end of his program.

This type of program appears to be an excellent vehicle for the student who plans a career in agribusiness, either in an operating or a staff capacity. A student interested in further graduate work would not be helped as much. Further graduate work would require more statistics and mathematics than completed by students on this program.

Even though the trainee does not remain as an employee—the firm might not wish to hire him, or he may choose graduate school or another firm—the firm should gain from the work done by the trainee. In Farmland's case, the firm was able to complete several projects that were of interest to it. The experience of the first student was that his ancillary relationship to the Farmland organization actually made it easier for his special projects to be accomplished. He had no operating assignments competing for his time. Since Farmland regularly

recruits the University's graduates, the shared experience of the student trainee should assist other students in evaluating the firm. More efficient recruiting should result.

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Enhancing Mutual Benefits from Firm-Level Research Efforts

Lynn W. Robbins, Stephen B. Harsh, and John W. Allen

The food system is usually thought of as having a series of participants that includes consumers, retailers, wholesalers, processors, assemblers, farmers or ranchers, input manufacturers, and input suppliers. Although there are others, the university is one important participant omitted from that list. The omission is made by both food industry executives and university scholars. Excluding the university component from the food system diminishes the opportunities of interaction between agribusiness and the campus. Potential for reciprocal advantage through increased interaction would suggest considering the university as an integral part of the food system, although currently the industrial and scholastic activities have fairly large nonoverlapping parts (figure 1).

This paper discusses the potential for enlarging the UB intersection in figure 1 by enhancing the mutual benefits from firm-level studies such as those being conducted under existing research approval policies. Barriers blocking potential interaction and suggestions for suppressing them are analyzed with specific illustrations from a case example. Alternative activities for capturing benefits similar to those from firm-level research are also explored briefly.

Cooperation Impediments

Snodgrass, in his paper on off-campus work and study experience programs, concurs with the need for increased industry-campus cooperation: "The establishment of a relationship with cooperators (in intern programs) can reduce 'isolationism' of the college and result in a better rapport with the commercial community, . . ." (p. 20). Similarly, Scroggs believes that "universities must maintain closer touch with industry to maintain their relevancy" (p. 885). Before regular university-agribusiness collaboration can become a reality, existing impediments must be resolved.

Apparently, university agribusiness research has placed primary and possibly singular emphasis on theory development and testing. Over time this approach has nurtured managers' beliefs that university researchers are unable to be practical. This mistrust has yet to be overcome.

Lynn W. Robbins is an assistant professor, University of Kentucky, and Stephen B. Harsh is an associate professor and John W. Allen is a professor, Michigan State University.

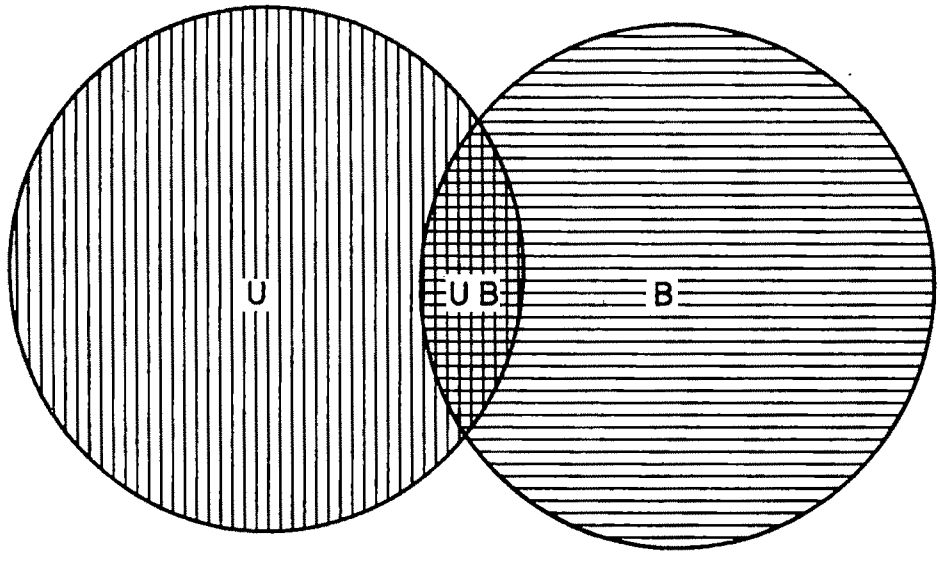
Reliance on universities for firm-level research is contrary to normal processes, especially within firms that have developed internal research and service capabilities. Internal services, however, do not always exist in needed areas, especially in smaller firms that have little or no staff support. Universities could potentially provide those abilities that are required to solve problems but that are not attainable within the firm. Where such opportunities exist, often the fear of disclosing operational methods plays a large role in a firm's hesitancy to rely upon university resources. There are, however, many industry-wide, nonspecific needs of the food system where disclosure is not a problem (Bloom).

Another barrier is the university's concern that its coveted neutral position will be violated. Many universities seem to dislike being associated with overt sponsorship of business, but greater interaction with agribusiness might lead to more applicable research and theory without having disproportionate distributional effects within agribusiness industries or between the public and private sectors. Neutrality would at least become less important to all directly involved as the additional university and societal benefits are recognized and captured.

What form should joint research assume? This question is the neutrality argument's central issue. Some argue that only publicly supported joint efforts are justifiable and most firm-specific problems cannot be publicly supported. Firm-level problems are then left to internal staff or external consultants. Accordingly potential benefits from mutual activity can only come from approved professorial consulting. Firms would not be allowed to contract university services in solving firm specific problems.

Shaffer "would restrict studies of efficiency at the firm level or below to the following: (*a*) Where the research is directly tied to an extension program and immediate use of results by competitive firms unable to finance their own research is highly likely. (*b*) Where the research ties to a broader subsector problem or study and thus has a public significance. (*c*) Where new methodology is being developed or tested. (*d*) Where the research is primarily a training exercise" (p. 8).

This policy suggestion for only publicly funded research obviously does not preclude joint research or its benefits. However, the issue in this paper is not that of defining what is proper joint research. The intention is to demonstrate the value of ex-



U = University sector

B = Agribusiness sector

Figure 1. Apparent university-agribusiness consensus on the optimum extent of beneficial mutual activities

panding university-agribusiness interaction within established policies, whatever they are, because historically mutual research benefits have been defined too narrowly.

Multiple facets are added to this "propriety debate," if private funding is allowed, in prescribing the firm's share of the financial support. Here, the prescription is only mutual payment for mutual benefits. Subsidy proportions have to be decided on a case-by-case, private treaty basis. The initial problem is not one of defining financial shares when mutual benefits exist; rather, it is the more basic problem of recognizing mutual benefits.

The Nature of University Research

Joint research efforts can provide increased university-agribusiness interaction. Indeed, university research programs often include studies that use company-specific data, but few are built directly around company-specific problems. Although this process imposes additional restraints upon the researcher, it is possible that research applied to actual business situations can result in an effective means of demonstrating the usefulness and validity of theory.

Dobson and Matthes contend that much university research is inadequate for industry use (pp. 557–64) because it often is either too technical to be readily interpreted or not timely enough to be useful. Results, as well as all other information communicated to managers, must be clear and straightforward. This means keeping mathematical formulae and disciplinary jargon to a minimum. It requires constant surveillance of legal, political, social, and physical feasibility with respect to research and social implementation; otherwise, solutions may be proposed that are theoretically valid but not realistic. For example, it may be politically infeasible to eliminate marginal farm supply cooperative dealerships if the goal is to emphasize member services even though the policy would be economically feasible.

Grayson extends Dobson and Matthes's argument by relating his experience as chairman of the Price Commission. In his opinion, "Managers and management scientists are operating as two separate cultures each with its own goals, languages and methods. Effective cooperation and even communication between the two is just about minimal" (p. 41). He explains that academicians want to help managers produce more explicit decision making through scientific methodology. Managers, on the other hand, "make and implement decisions largely by rough rules of thumb and intuition, . . ." (p. 42).

These positions are incompatible. Grayson discovered what he thought were the reasons for this incompatibility. When "putting together the Price Commission, (he) used absolutely none of the management science tools explicitly, . . ." (p. 43). He could not use them because of shortage of time, inaccessibility of data, resistance to change, long response time, and invalidating simplifications.

Company-specific research could adjust economic, marketing, and management tools to more adequately solve industry problems within industry constraints. Unlike company executives, university researchers are free to contend with technique inadequacies without interference from the firm's day-to-day responsibilities. Once implementation techniques are developed, however, managers should be able to apply them in the face of constraints such as those suggested by Grayson.

An Example

Applied firm-level research is one method for members of the university and agribusiness groups to discover, delineate, and enlarge the UB intersection (figure 1). A recent research effort contracted by the Michigan Farm Bureau's Supply Division is an example (Robbins). Farm Bureau management contracted with Michigan State University to compare projected assembly, distribution, and warehouse costs to those of a one-warehouse system. These comparisons were to provide information needed for deciding whether to invest in a one-warehouse system and to identify the ideal site for such a system.

Outside research was used because management's internal investigation had been too superficial. The major elements of the firm's estimates, managers' knowledge of warehousing technology and their familiarity with Farm Bureau warehouses, were insufficient confidence builders. The dilemma was that the Farm Bureau had neither the time nor the human resources required to internally obtain that information, but they possessed the financial capability to purchase those resources from the university.

Initially, the Farm Bureau was concerned over data confidentiality. Early planning included a disclosure agreement. The foundation for experiment station approval of any research is total data disclosure. The agreement met the full disclosure condition by requiring an initial understanding that all data required for the research effort could and would be provided. The requested data's specific form and detail were left to Farm Bureau's management. The managers' trade-off decision was between data sensitivity and potential solution accuracy. Data needs were presented to management for sensitivity evaluation. None were censored. As new data needs emerged, Farm Bureau screened them according to the agreement. Ultimately, the fear that university research might disclose classified data subsided as the Farm Bureau managers' confidence in university researchers grew. As a result, data disclosure did not hinder the research process.

A review of Farm Bureau's early internal study reinforces the virtue of its decision to ask for outside assistance and confirms the suspicion that the internal research was too perfunctory. For example, preliminary research had correctly identified the central warehouse location using an ordinal ranking approach but did not show that the cost differentials were small.

The research contract provided an opportunity to explore the applicability of research techniques to common agribusiness problems of plant size and location. Techniques used were unique to economies of size and location analyses due in part to limitations imposed by actual agribusiness constraints. For example, an apparent straightforward application of transshipment linear programming was compounded by backhaul requirements until a modification of Schruben and Clifton's lockset model was required (Robbins, pp. 48–49).

The importance of research timeliness was illustrated by Farm Bureau's requests for rough first approximation studies soon after the project started. Schedule adjustments were made to allow concentration on areas that were either previously not scheduled or set for a later time, and interim reports were submitted regularly.

In addition to the benefits of added information the study provided Farm Bureau with an opportunity to improve the return on its investment from the contracted research. The Farm Bureau could realize this return by using computer models specifically designed for the research project, yet applicable to normal operating decisions. The routing algorithm could be utilized as an aid in daily route structuring, and warehouse simulators could be used in ordering and inventory strategy as well as labor force planning.

Conclusions

Joint research benefits from one case study say little about the value of similar additional efforts. Indeed, the marginal return to the university of exactly duplicating the Michigan Farm Bureau research would likely be small. Researching a similar problem with another firm might allow discovery of an even more efficient application of theory and would add university familiarization with another type of agribusiness firm.

The largest marginal return from added firm-level research will most likely come from studying unique firm problems that arise across the entire range of agribusiness types. Apparently, solutions are needed for that set of firm-specific problems for which current university research has been labeled inadequate.

Joint university-agribusiness research conducted under existing policies provides university personnel with insights beyond those gained from less pragmatic efforts. Applied research not only demonstrates theory's usefulness and validity but it also updates the researchers' industry knowledge. University personnel can enhance their teaching by bringing realism into the classroom and can conduct more effective research by obtaining detailed information with respect to how agribusiness firms are organized and managed.

Currently, acceptable firm-level research can provide greater benefits than are generally realized. However, research is not the only source of mutual benefits. Industry and related university departments can do more to achieve the kinds of goals discussed. Together they can establish improved cooperative education programs and other learning-by-doing methods. University staff might become involved with industry issues in other than a consulting or staff role. Such relationships can build understanding and empathy for the food industry that has not previously existed in academia.

Agribusiness firms might provide executive-instructors and finance mutually beneficial research. Executives can also be more specific as to ability areas desired in job applicants.

The goal of determining the full range of effective instruments for achieving cooperation remains largely unfulfilled. Graduate and undergraduate intern programs, faculty consulting, extension programs, executive lectures, and funds for contracted research are among the techniques currently used. Faculty-executive exchange sabbaticals, graduate student apprenticeships, and joint university-agribusiness advisory boards (for coordinating agribusiness research, teaching, and extension efforts at the regional, state, and national level) are other techniques (Scroggs).

Nevertheless, greater recognition of the need for cooperative efforts in more university and agribusiness activities has developed. Recently, an "Open Letter to the Members of the Agricultural Economics Profession" from the AAEA Industry Advisory Committee urged "the profession to review the recommendations that have been placed before it in recent annual meetings and to develop research and training programs that incorporate as many of the recommendations as possible. The committee also invites comments from others in the profession as to how industry could expand its role in narrowing the gap that has developed in our profession." The need is to restructure existing university-agribusiness relationships and obtain greater joint benefits.

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of New England and the Chesapeake region, there is never any data on real output and human life in the two regions during the period when their land tenures differed.

Of course, in the Anderson and Hill model any detailed reference to the substance of performance is beside the point because the real purpose is to theoretically legitimatize a particular institution, not to provide information on institutional-performance linkages, so that people could support the institution that serves their particular interests best. It is time to make the economics of property rights analytical rather than value presumptive.

It is also time to remove the artificial wall between distribution and production. If we read our history better and look about today, we may find that, when people feel they are being fairly treated, they make greater effort. The marginal product of labor is not a given but is affected by peoples' view of equity.

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The Role of Private Property in the History of American Agriculture, 1776–1976: Reply

Terry L. Anderson and P. J. Hill

Schmid is accurate in his opening statement regarding the "relative neglect" and "growing literature on the economics of property rights," and we would hasten to add that this renewed interest in the subject should contribute significantly to our understanding of individual and collective behavior. While Schmid concedes that our article is an example of the renewed interest, he probably would not consider it a "significant" contribution. His basic criticisms fall into the following four categories: (*a*) the data are too sparse and misrepresent what was actually occurring; (*b*) the analysis ignores losers when in fact distribution is important; (*c*) the theory is at best incomplete; and (*d*) the "real purpose is to theoretically legitimatize a particular institution." We respond to each of these in turn.

The data that can be presented in a short paper covering 200 years of agricultural history must be limited and chosen carefully, and we make no claims that our data series are complete. Nonetheless, those data present a reasonably accurate historical sketch or summary statement. Obviously, not all topics in American agricultural history could be discussed. Schmid raises some issues that he considers more important and implies that our sample of history is biased. However, what he calls "selective perception," we would term "attempts to characterize briefly." In spite of Schmid's examples, we stand by our original statement that the nineteenth century "can be characterized as a period of rapid establishment of individual rights" (p. 940). This characterization does not preclude collective action, and indeed we cite examples. Schmid points out others and emphasizes the importance of collective action with the example of attempts to control tobacco production in the 1630s. Was it "selective perception" that led him to ignore that such collective action failed? On the page after the one quoted by Schmid, Edwards indicates that the attempts at limitation were not successful (p. 185).

Turning to Schmid's second criticism, we do not deny that questions involving distribution of wealth are important, but we also believe that questions involving how institutions affect the absolute level of wealth are at least equally important. The record of private property institutions in promoting efficiency is well documented (Furubotn and Pejovich). The point that Schmid seems not to recognize is that the move from systems of communal rights to private rights is not a zero-sum game. What happened to the colonial shirkers or the man who lost his common law claim on water are interesting questions. But the whole point of Pareto efficiency that comes with private ownership is that all can be made better off. There is nothing a priori to suggest Schmid's emotional conclusion that the man who lost his common law claims "went hungry." By definition, improvements in efficiency are positive-sum games.

Schmid, with his concern for distribution issues, seems to be offering an implicit hypothesis: if there had been less private property in American agriculture, the "problem of poverty or backward regions" would have been reduced. Is it more likely that the problems of poverty will be eliminated if we choose to ignore efficiency and concentrate entirely upon distribution? We think not. Efficiency may not be a sufficient condition for social welfare maximization, but it is necessary.

Third, Schmid is concerned that our "theory suggests no other possible source of rights change, so it never occurs to them to look for other possible explanations" than economic variables. To say the theory suggests "no" other sources of change is false. We do "note" (we thought we did more than note) that ideology is a factor. As is clear in our other work (1975, 1976, 1977), the marginal effectiveness of efforts to alter property rights is a function of "such conditions as cultural and ethical attitudes, the existing rules of the game or the institutional structure, historical precedent, the decision making rule, . . . , to mention a few" (1977, p. 13). This hardly seems to argue that economic factors are solely responsible for institutional change or that government is "passive and neutral." To the contrary, if we are to understand the evolution of the institutional system, we must concentrate more on political, philosophical, and legal conditions. These all influence the willingness of individuals to attempt change and the ability to achieve success. However, we also believe that economic factors cannot be ignored and that differences in relative prices go a long way in explaining differences in behavioral responses. Thus, differences in scarcity of land are a prime explanatory variable in explaining land tenure patterns. Schmid's addition of

Terry L. Anderson is an associate professor in agricultural economics and Peter J. Hill is an associate professor in economics, Montana State University.

"rules of popular access to government" may add to the explanatory power of the model. Further work in this area is encouraged.

Finally, we turn to the comment that "the real purpose is to theoretically legitimatize a particular institution." Our argument that private property promotes efficiency by equating private and social rates of return is straightforward. The first half of U.S. agricultural history can be characterized as a move towards private property. Efficiency resulted. If this legitimatizes an institution, so be it.

Schmid acknowledges this "role of private property in motivating effort" but contends that there are other legitimate means to this end. We agree but do not regard the Ciriacy-Wantrup and Bishop article as evidence "that many of the world's communal lands were well managed and preserved and did not suffer what is now mistakenly assumed to be the inevitable 'tragedy of the commons.'" Ciriacy-Wantrup and Bishop do not demonstrate the efficacy of communal property. They simply offer several ways in which private rights can be partially assigned through quotas, fishing seasons, controls on number of cattle that could be grazed on communal pastures, and other institutional regulations. Rather than being a defense of common property, as Schmid sees it, the article is a strong argument for the necessity of additional institutional arrangements to make common property functional.

Almost half of our paper deals with the twentieth-century movement from efficiency to equity questions as the major focus of institutional change. Schmid does not comment on this. Is this focus an attempt to legitimatize a different institution that Schmid finds more pleasing? Hardly. This focus is a result of our theory and the variables that changed during the last quarter of the nineteenth century. To be sure, additional testing is necessary and revisions in the theory will likely occur. We hope our paper stimulates such work.

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Prices and Demands for Input Characteristics: Comment

Randall E. Westgren and Lee F. Schrader

Ladd and Martin have modeled the demand for corn as neoclassical input characteristics (derived) demand. Their theoretical model is a variant of neoclassical firm theory, where the intrinsic characteristics of corn are the arguments in the processor's demand function. Following a discussion of firm theory, two empirical applications cast in linear programming framework are offered.

The second of two blending problems presented, wherein bins or carloads of corn with known characteristics (grade factors) are blended into lots of U.S. grades 1, 2, 3, 4, and 5 yellow corn so as to maximize gross return, is improperly formulated. The empirical formulation offered by Ladd and Martin for this problem is inconsistent with their theory and can be shown to yield a technically infeasible solution. This note provides an alternative formulation that is technically feasible and consistent with their theory.

In the Ladd and Martin paper the profit-maximizing behavior of the firm is stated as

$$\max \sum_j c_j x_j \tag{1}$$

subject to

$$\sum_j a_{ij} x_j \begin{bmatrix} \leq \\ = \\ \geq \end{bmatrix} r_i \quad \text{for} \quad i = 1, \ldots, m \tag{2}$$

and

$$x_j \geq 0 \quad \text{for} \quad j = 1, \ldots, n, \tag{3}$$

where x_j is the quantity of jth output blended, c_j is the gross revenue per unit of jth output, a_{ij} is the amount of ith characteristic per unit of jth output, and r_i is the total stock of ith characteristic (from all bins).

This model fails to recognize that outputs are produced from linear combinations of input characteristic bundles and that an input characteristic cannot be independently drawn from a source without also drawing other characteristics, in fixed proportion, from the source.

Alternatively, the formulation of the problem should appear as

$$\max \sum_j c_j x_j \tag{4}$$

subject to

$$\sum_k b_{ik} z_{kj} - a_{ij} x_j \begin{bmatrix} \leq \\ = \\ \leq \end{bmatrix} 0 \tag{5}$$

$$\text{for} \quad i = 1, \ldots, m \quad \text{and} \quad j = 1, \ldots, n,$$

$$\sum_k z_{kj} - x_j = 0 \quad \text{for} \quad j = 1, \ldots, n, \tag{6}$$

$$\sum_j z_{kj} \leq r_k \quad \text{for} \quad k = 1, \ldots, p, \tag{7}$$

and

$$z_{kj}, x_j \geq 0 \quad \text{for} \quad k = 1, \ldots, p \quad \text{and} \quad j = 1, \ldots, n, \tag{8}$$

where b_{ik} is the quantity of characteristic i per unit of corn in bin k. a_{ij} is the quantity of characteristic i per unit of output j, z_{kj} is the quantity of corn from bin k used in output j, x_j is the quantity of output j produced, c_j is the gross revenue per unit of jth output, and r_k is the stock of corn available in bin k.

This is a larger problem. One constraint exists for each of the i characteristics for each of the j outputs rather than for each of the i characteristics only. Thus, there are mn equations of type (5), n equations of type (6), and p volume control equations describing the problem. The Ladd and Martin formulation includes a constraint for each of the i characteristics and a single volume control equation.

Four carloads of corn with characteristics described in table 1 are blended according to the Ladd and Martin formulation, equations (1) through (3), and the revised formulation, equations (4) through (8). The market prices for the five grades are taken from the Ladd and Martin article and are presented at the bottom of table 2.

The Ladd and Martin formulation has five output grade producing activities with four characteristics rows (test weight, moisture, BCFM, and damage) and a weight control row. (The a_{ij} terms are taken from Ladd and Martin, table 1.) The right-hand side column contains the sum of the characteristics available and weight of the corn in the four carloads.

The alternative problem repeats each of the four characteristic equations (type (5)) and the "adding up" restriction (type (6)) for each of the five output grades and contains a volume control equation (type (7)) for each carload. This formulation has twenty input activities (four carloads by five output possibilities) and five output producing activities.[1]

Randall E. Westgren is a graduate research assistant and Lee F. Schrader is a professor in the Department of Agricultural Economics, Purdue University.

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[1] The a_{ij} terms are the same as for the Ladd and Martin formulation, and the b_{ik} terms are taken from Ladd and Martin (table 1).

Table 1. Carload Characteristics

Characteristic	Carload Number 1	2	3	4
Test weight	57	54	52	50
Moisture	0.14	0.16	0.18	0.20
BCFM	0.03	0.04	0.07	0.03
Damage	0.03	0.02	0.10	0.06
Carload volume	3,300	3,300	3,300	3,300

Solution values for the two problems are presented in table 2. The Ladd and Martin formulation produces 11,220 bushels of U.S. no. 2 corn and 1,980 bushels of U.S. no. 4 corn, compared with 9,900 bushels of U.S. no. 3 and 3,300 bushels of U.S. no. 4 corn blended by the alternative formulation. Hence, there is a $1,168 loss in gross revenue associated with the corrected formulation. The Ladd and Martin formulation produces an infeasible solution. The maximum allowance for BCFM in no. 2 corn is 0.03. With carloads 1 and 4 at the limit, and 2 and 3 above the maximum allowance, no more than 6,600 bushels of no. 2 can be produced by ordinary blending procedures. The shadow price generated by the broken corn and foreign material constraints are chosen for illustration and show that the aggregation of the resources by the Ladd and Martin technique results in a zero shadow price for the constraint, while the revised model gives positive shadow prices for all but the U.S. no. 5 BCFM constraint.

The revised formulation of the Ladd and Martin corn blending problem is consistent with their neoclassical input demand model. In the theoretical model they quite properly maintain the identity of inputs into the independent production processes; that is, their production function maintains the identity of inputs into a single production process.[2] Their blending problem formulation ignores this identity and, as originally formulated, is less restrictive than the theoretical model. The revised formulation results in a feasible result, whereas the original problem is likely to result in a technically infeasible solution.

Table 2. Comparison of Results

	Ladd and Martin	Revised
Objective function[a]	$12,784	$11,616
Quantity produced		
U.S. no. 2	11,220 bu.	—
U.S. no. 3	—	9,900 bu.
U.S. no. 4	1,980 bu.	3,300 bu.
Shadow price		
BCFM	0	—
U.S. no. 1 BCFM	—	48.43
U.S. no. 2 BCFM	—	98.22
U.S. no. 3 BCFM	—	12
U.S. no. 4 BCFM	—	12
U.S. no. 5 BCFM	—	0

[a] Given market prices of $1.00, $1.00, $0.91, $0.79, and $0.63 for U.S. grades 1 through 5 yellow corn.

Ladd and Martin draw upon the results of their linear programming analysis to show that the present corn grading system cannot meet a desirable condition of "sign-optimality." The results of revised formulation supports these conclusions. Clearly, the difference in shadow prices for the same characteristic within the firm renders the notion of condensing corn quality to a single number even more questionable. One is tempted to hypothesize that the marginal value of a particular lot of corn is most likely to depend on one or two critical characteristics rather than any given set which may be used for grade determination.

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[2] The production function appears as $q_h = G_h(v_{1h}, v_{2h}, \ldots, v_{mh}, x_{11h}, x_{12h}, \ldots, x_{mnh})$, where v_{ih} is the quantity of the ith input used in the production of the hth product, x_{jih} is the amount of characteristic j provided by one unit of input i that enters into production of product h, and $x_{j \cdot h}$ is the total quantity of characteristic j that enters into production of product h (g_n).

Reference

Ladd, George W., and Marvin B. Martin. "Prices and Demands for Input Characteristics." *Amer. J. Agr. Econ.* 58 (1976):21–30.



Prices and Demands for Input Characteristics: Reply

George W. Ladd

This reply covers four topics: (*a*) a brief comparison of the Westgren and Schrader (WS) and the Ladd and Martin (LM) formulations of blending processes in multiproduct plants, (*b*) a brief comparison of objective functions in the two models, (*c*) derivation of shadow prices of characteristics from the WS model, and (*d*) reevaluation of evidence on sign-optimality of the present corn-grading system.

The statement of blending processes in the WS formulation of the second blending problem is clearly superior to the formulation in the LM paper. However, the LM model maximizes net revenue. WS maximize gross revenue. For reasons presented later, I believe that maximization of net revenue is more appropriate. The rest of this reply deals with a WS model in which the objective function has been changed to net revenue and which is referred to as the "revised WS model."

The shadow prices for corn yielded by the revised WS model can be used to determine if a grading system satisfies the LM criterion of sign-optimality and for other purposes. The shadow prices for corn characteristics yielded by the WS model, however, are not useful for evaluating grades because they do not measure the effect on cost or on revenue of varying the amount of characteristic in a product or input.

The interpretation of the shadow prices is clarified by looking at the dual to the revised WS program. The revised WS model contains one constraint for each characteristic in each output. These constraints are represented by expression (5) in the WS paper. Assume all these constraints are of the form

$$(5WS) \qquad a_{ij}x_j - \sum_k b_{ik}z_{kj} \leq 0.$$

Then the dual to the revised WS program is

$$(1) \qquad \min G = 0\sum_i \sum_j v_{ij} + 0\sum_j u_j + \sum_k y_k r_k$$

subject to

$$(2) \qquad \sum_i a_{ij} v_{ij} - u_j \geq c_j \text{ for } j = 1, 2, \ldots, n,$$

$$(3) \qquad y_k - \sum_i b_{ik} v_{ij} + u_j \geq 0 \text{ for } j = 1, 2, \ldots, n \text{ and } k = 1, 2, \ldots, p,$$

and

$$(4) \qquad \text{all } v_{ij}, y_k \geq 0, \text{ all } u_j \text{ unrestricted.}$$

The dual variables can be defined as v_{ij} is the shadow price of characteristic i in product j, u_j is the shadow price of WS product balance equation (6), and y_k is the shadow price of corn in bin k.

If the amount of corn in bin k is increased by the amount dr_k, where the added corn has exactly the same combination of characteristics as the corn originally in the bin, then

$$(5) \qquad d(\max \sum_j c_j x_j)/dr_k = d(\min G)/dr_k = y_k,$$

where y_k measures the effect on net revenue of varying by one unit the available amount of corn having the same set of characteristics that the corn in bin k has and where y_k is the maximum price the firm can afford to pay for such a unit of corn. If it pays more than y_k, its net revenue will be reduced.

To interpret the v_{ij}, rewrite expression (5WS) as

$$(5WSa) \qquad a_{ij}x_j - \sum_k b_{ik}z_{kj} \leq -E_{ij}.$$

If $E_{ij} > 0$, equation (5WSa) states that the total amount of characteristic i taken from all bins for use in product j shall exceed the amount actually used in product j by the amount E_{ij}. (What happens to the surplus of characteristic i?) If $E_{ij} < 0$, equation (5WSa) allows the amount of characteristic i actually used in product j to exceed the total amount of characteristic i taken from all bins to use in product j. (Where does the rest of the characteristic i needed for product j come from?) A nonzero value of E_{ij} either forces waste on the firm or has a nonsense meaning. If $-E_{ij}$ is varied by the amount $d(-E_{ij})$, then $d(\max \Sigma c_j x_j)/d(-E_{ij}) = d(\min G)/d(-E_{ij}) = v_{ij}$. The shadow price v_{ij} measures the effect on revenue of varying the artificial waste or deficit requirement by one unit. A characteristic's shadow price having this interpretation does not seem useful to me. It does not measure the value to the firm of having more or less characteristic in an input or output. It only measures the value of varying an artificial requirement of surplus or deficit.

Characteristics' shadow prices that would be useful for evaluation of grades are obtained by answering the question, "What happens to maximum net revenue if the amount of one characteristic in a bin is increased?" Let s_{fg} equal amount of characteristic f in bin $g = b_{fg} r_g$, and suppose s_{fg} increases by the amount ds_{fg}. What happens to maximum net revenue? Duality theorems will not provide an answer to this question because s_{fg} is not an explicit parameter in the linear program. Changing s_{fg}

George W. Ladd is a professor of economics, Iowa State University.

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changes r_g, and it also changes the b_{ig} coefficients; $db_{ig}/ds_{fg} = (r_g ds_{ig}/ds_{fg} - s_{ig} dr_g/ds_{fg})/r_g^2$, where $ds_{ig}/ds_{fg} = 0$ unless $i = f$. The resulting change in max $\Sigma c_j x_j$ can be obtained from a relation in sensitivity analysis (see Gass, pp. 139–40). If the changes in r_g and the b_{ig}'s do not cause a change in the optimal feasible basis, then

$$(6)\quad d(\max \Sigma c_j x_j)/ds_{fg} = \sum_{i=1}^{m}\sum_{j=1}^{n} z_{gj} v_{ij} (db_{ig}/ds_{fg}) + y_g (dr_g/ds_{fg}) \gtreqless 0.$$

Denote the right-hand side of equation (6) by w_{fg}, where w_{fg} is the maximum amount the firm can afford to pay for an increase of one unit in the amount of characteristic f in bin g. The value of w_{fg} can be easily determined from the solution to the primal linear program. After ds_{fg} is specified, the values of the derivatives can be determined. The linear programming solution provides the values of the primal variables z_{gj} and the dual variables v_{ij} and y_g. If the changes in r_g and the b_{ig}'s do cause the optimal feasible basis to change, the value of w_{fg} is obtained from

$$(7)\quad w_{fg} = \max \Sigma c_j x_j' - \max \Sigma c_j x_j,$$

where max $\Sigma c_j x_j$ is the maximum feasible value of the WS objective function for the original linear program and max $\Sigma c_j x_j'$ is the maximum feasible value for the linear program obtained by changing the values of r_g and the b_{ig}'s.

Equation (6) shows that w_{fg} may not equal w_{ft} $(t \neq g)$ even though $ds_{fg} = ds_{ft}$. The contribution to net revenue of increasing the stock of characteristic f by one unit depends upon the characteristics of the corn in the bin to which the addition is made.

As stated earlier, I believe that for purposes of evaluation of grades it is better to use net revenue rather than gross revenue as the objective function. To understand this, assume the objective function is gross revenue. Then $d(\max \Sigma c_j x_j)/dr_k = y_k$ measures the effect on gross revenue of increasing r_k. But y_k exceeds the maximum amount the firm can afford to pay for an additional unit of corn having the same combination of characteristics as the corn in bin k. If the firm pays y_k for the corn, its net revenue is reduced by the amount it costs to blend this additional corn. If the cost of using additional stock of corn is independent of the bin to which it is added (i.e., independent of the combination of characteristics in the addition) and also independent of the product in which it is used, then $y_k - t$ is the maximum price the firm can afford to pay for the corn, where t is the cost of using an additional unit of corn. By a similar argument, w_{fg} overstates the maximum amount the firm can afford to pay for an increase of one unit in the amount of characteristic f in bin g. If the cost of using this additional stock of characteristic is independent of characteristic, bin, and product(s) in which it is used, then $w_{fg} - T$ is the maximum price the firm can afford to pay, where T is cost of using the additional stock of the characteristic.

To write net revenue as $\sum_j c_j x_j$ means that c_j is the net revenue per unit of output $j = p_j - t_j$, where p_j is the selling price and t_j is the variable cost of blending one unit output j. All t_j's may have the same value. The variable cost of blending one unit of output j may depend upon the bin from which the inputs for the product are taken (e.g., upon the combination of characteristics in the bin, or the location of the bin). Then, net revenue can be expressed as

$$(8)\quad \sum_j p_j x_j - \sum_k \sum_j t_{kj} z_{kj} = \pi,$$

where t_{kj} is the average variable cost of using one unit of input from bin k in output j. If the WS objective function is replaced by equation (8), the dual constraints (2) and (3) become

$$(9)\quad \sum_i a_{ij} v_j - u_j \geq p_j$$

and

$$(10)\quad y_k - \sum_i b_{ik} v_{ij} + u_j \geq -t_{kj}.$$

Then $d(\max \pi)/dr_k = y_k$ from equation (5) and $d(\max \pi)/ds_{fg} = w_{fg}$ from equation (6). Replacing the WS objective function by equation (8) does not change the expressions used to obtain y_k and w_{fg} but can change the values of y_k and w_{fg} because changing the objective function can change the solution values of primal and dual variables.

The LM paper relies on three pieces of evidence to support our position that the present corn-grading system is not sign-optimal and our suggestion of the specified-order method of reporting: (*a*) our linear programming results, (*b*) marginal value products (MVP's) that Knapp obtained for some 190 bins of corn in a corn merchandising study, and (*c*) corn users' rankings of importance of various corn characteristics. The WS comment makes it clear that our linear programming results cannot be relied upon. But the other two pieces of evidence support our position. Nothing in WS or in this paper affects the LM interpretation of the ranks assigned by corn users.

Knapp's MVP's are equal to y_k from equation (6) plus the cost of using a bushel of corn from bin k. Let y_k be the MVP of a bushel of corn of grade k (k = 1, 2, 3, 4, 5, and 6; 6 indicates sample grade) and t_k be the cost of using a bushel of corn of grade k. Knapp's results are inconsistent with sign-optimality for every value of k and i that satisfy

$$(11)\quad \max y_k + t_k \geq \min y_{k-i} + t_{k-i}.$$

If the cost of using a bushel of corn is not affected by grade, then $t_k = t_{k-i}$ and all of Knapp's results are inconsistent with sign-optimality because max $y_k >$ min y_{k-1} for all k. Likewise, if $t_k > t_{k-1}$, all Knapp's results are inconsistent with sign-optimality. His results are also inconsistent with

sign-optimality in many cases in which $t_k < t_{k-1}$. For example, if $t_5 - t_6 = 0.08815$, his MVP's are inconsistent with sign-optimality for some bins of U.S. no 5 and U.S. sample grade corn.

A question has been raised (not by WS) about the nature of the inequalities in table 1 of the LM paper as well as the results in table 2. Tables 1 and 2 in the LM paper are consistent. The problem in table 1 is exactly problem 11 whose solution is presented in table 2 and is representative of the other problems whose solutions are presented in table 2. The problems would have been more realistic, however, if all constraints had been of the "less than or equal to" form: $\Sigma a_{ij}x_j \leq a_{i0}$. If all constraints in table 1 were of this form, the only nonzero shadow prices in table 2 would be those for damaged kernels. These shadow prices would all be \$33.33 per bushel.

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Books Reviewed

Breimyer, Harold F. *Economics of the Product Markets of Agriculture*. Ames: Iowa State University Press, 1976, x + 208 pp., $11.95.

The theme of this book is set in the preface: "the ideas contained herein are designed to fit traditional courses in agricultural economics yet are also intended to lead the student into explorations that may be distinctive and in instances unconventional" (p. ix). This is a textbook on agricultural product marketing designed for upperclass or beginning graduate instruction and a book in which traditional concepts in agricultural marketing and principles of industrial marketing are drawn upon separately and together. The result is a partial "redesigning of the analytical structure" (p. ix).

Breimyer has utilized his years of experience and broad knowledge as an authority in agricultural marketing to put together an interesting, provocative text. He presents new conceptual frameworks for often old ideas and melds together differing opinions that make for intriguing contemplation. It is a book all students of marketing will want to read. Its style is clear and easy reading, but stimulating.

In most classroom situations, this text will probably not stand alone. First, most of the "[b]asic ideas are presented in summary form and rapid order, without detailed elaboration" (p. ix). However, Breimyer has done an excellent job of citing the literature so the student can easily refer to the underlying arguments and logic of basic notions. Second, this book focuses in a descriptive manner on the economic concepts relating to the market mechanism, and it is not a how-to-do-it marketing book. It is nontechnical, without voluminous tables of data, and contains minimal references to empirical work.

The first four chapters lay out the fundamental concepts in which the author goes beyond conventional wisdom and suggests alternative model formulations. The first chapter points out the diversity of alternatives when examining systems of economic organization, organizational structure of marketing, and definitions of marketing. No stand is taken on the issues presented, although the author presents his version of the evolution of agricultural marketing through four epochs. Chapter II fits least well in the text and examines goals of consumers and firms from the standpoint of how to judge the performance of the economic system towards meeting these goals. Standard utility theory is relied upon, but despite the author's criticism of theoretical economists, the problem of evaluation remains.

The next two chapters present the basic conceptual frameworks. Chapter III rules out traditional neoclassical analysis and presents the economics of the firm in an imperfectly competitive structure. A theory of full cost pricing is described, where costs are divided into three groups, controllable variable, specific overhead, and general overhead. Oversimplifying, full cost pricing is an accounting device whereby a multiple product firm, like a retail food store, prices products with varying markups; that is, the overhead is not apportioned evenly among products but is divided according to the competitive nature of the various products.

Chapter IV discusses the structure of markets in standard terms. Imperfectly competitive markets are emphasized, and rightly so, and the variables examined are those typically used in most structure-conduct-performance analyses. Special attention is given to vertical relationships, an overriding concern throughout the text. One anomaly stands out in these conceptual chapters. Considerable effort is made to reject marginal analysis and substitute descriptive frameworks. Yet, when the subject of price discrimination (market stratification) is discussed, the standard model in which marginal cost is equated to marginal revenue is presented.

The remainder of the book is more empirical or problem specific. Nevertheless, the theories laid out above in addition to notions of limited divisibility and mobility of resources, and the impact of firms operating at less than full capacity, are continually referred to and act as common threads of analysis. Subjects discussed include the standard breakdown of the consumer dollar (appropriate caution is given about the unreliability these data have as a measure of market performance), structure of the farm marketing, processing, and retailing sectors, price discovery systems, and research on the performance of the marketing system. Continual reference is made to the significant findings of the National Commission on Food Marketing, but that in itself, plus reminders through the text, reveals the need for an update. The book points out how much we do not know and that we are lacking critical data for market analysis, especially in vertical coordination arrangements and industry specific information about conglomerates.

Governmental policies affecting marketing, economics of (railroad) transportation, theory of firm location, and marketing in economic development complete the book. Each of these topics is handled briefly, raises some structure-pricing-performance issues, but leaves the resolution to others.

One disappointment of mine is in a topic not covered. On page 9, Breimyer lists the marketing functions found in standard texts and in one fashion or another discusses all of them but one—risk bearing. This topic, or the more broadly construed topic of risk management, ought to be confronted directly

in a marketing text. The importance of this area has increased with the increased price volatility of the 1970s, and recent methodological breakthroughs have led an upsurge of both theoretical and empirical literature. Certainly, one of the underlying impetuses for various vertical coordination arrangements is the firms' attempt to manage risk. Breimyer's well-known underlying preference towards traditional agriculture, especially in pricing, creeps into this book also. In this regard, I have argued before that the most visible forward contracting market, the futures market, helps preserve the traditional markets by providing large firms an alternative for risk management other than vertical production or marketing contracts, or even conglomeration.

The author does an excellent job in referring the reader back and forth through the text to previously stated underlying arguments or subsequent elaborations of a point. Only once is this done excessively when on page 103 an illustrative sketch of food marketing is repeated from page 84, and one still wonders if there is significance to the size of boxes in the sketch. Also, some of the analytical frameworks are rather loosely described, which will leave technicians and theoreticians uneasy. Broad generalities and vague terms like "giant" and "probably" occasionally mar the quality.

Nevertheless, these minor complaints aside, Breimyer is a senior scholar and has provided us with a text that will serve as a basis for discussion for years. He has insight and creative abilities possessed by few people and an ability to communicate these thoughts so as to provoke the profession.

Raymond M. Leuthold
University of Illinois

Fuller, Anthony M., and Julius A. Mage. *Part-Time Farming: Problem or Resource in Rural Development.* Norwich, England: Geo Abstracts Ltd., 1976, 291 pp., price unknown.

The proceedings of a symposium on part-time farming held at the University of Guelph, Canada, are reported in this book. The symposium grew out of the co-editors' long-standing interest in part-time farming and the part-time farming research program of Guelph's Department of Geography. The stated objectives of the symposium are to (*a*) identify who are the part-time farmers, (*b*) assess whether part-time farming represents a problem or resource, (*c*) identify the relationship between newcomers to agriculture and part-time farming, and (*d*) identify some policy implications.

The major papers and discussion of the symposium are in three groups. The first group is conceptual in nature and sets the stage for the remainder of the conference. The second group focuses on problems associated with part-time farming, and the final group concentrates on policy implications.

The two papers in the first group have as their objective the development of a typology of part-time farming and a conceptualization of part-time farming problems. Part-time farming is defined as situations in which farm operators have remunerated nonfarm work. The role of nonfarm employment of farm family members other than the operator is not addressed in defining part-time farming. From the variety of part-time farming situations identified (small-scale hobby, large-scale hobby, aspiring to full-time, persistent part-time, and sporadic part-time), it is apparent that the part-time farming phenomenon is not simply the "opposite" of full-time farming. The problems of part-time farming are conceptualized in terms of two dimensions of time: work-time allocation and adjustment time. Several problems with allocation of time between farm and nonfarm employment are identified. The concept of adjustment time is used to identify problems associated with farm enterprise and rural life style change and personal and occupational mobility. The concepts developed in these papers are helpful and are likely to stimulate additional efforts to refine the concepts presented. They need to be tested in areas other than Ontario, Canada. Especially needed is an analysis of the impacts of cultural differences and specific economic factors such as land use patterns, nonfarm employment opportunities, and life cycles of farm businesses.

The second group of papers falls under the general heading of problems with part-time farming. The seven papers are grouped under four subheadings: economic marginality, physical marginality, newcomers to agriculture, and problem or resource. There is substantial variation in the focus, depth, and polish of these papers. Some are helpful because of their detailed empirical analysis and concentration on carefully defined issues. Economic and physical marginality are not clearly differentiated. The hobby farming discussion is helpful, but the problem of newcomers to agriculture is broader than hobby farmers. This section of the book would have benefited a great deal from introductory sections concentrating on problem definition and reasons for selection of countries and specific issues addressed.

The third group of papers is concerned with policy implications. A general lack of clarification of policy issues related to part-time farming is apparent from the three papers and the four-person panel discussion. Canada, Finland, Sweden, Italy, United States, and Britain are represented in the policy discussion. A common thread running through the papers is the limited attention to part-time farming issues by policy makers in these countries. However, there is a general consensus of no need for special policies to protect or promote part-time farming. The papers suggest that part-time farming may be an important part of the development strategy for some declining rural areas and some developing areas.

This volume also includes a conference summary, a paper presented at a special session on part-time farming in Poland, four papers in absentia, and a transcript of the participant discussion following each group of papers.

There is much in this book that will be helpful to the agricultural economist interested in part-time farming. The complexity of the research and policy issues is made apparent. The conference did not resolve whether part-time farming is a problem or a resource, but many hypotheses relative to this question were suggested. The conference did not accept the myth that all small-scale farmers are part-time and conversely that all part-time farmers are small scale. The need to go beyond a conceptualization of part-time farming as a transition stage for a farmer or an agricultural region is apparent. Data limitations and problems with much of the analysis that has been done to date are clearly identified.

There are some limitations to the book. Most relate to the inherent limitations of a three-day international conference dealing with complex issues. Although some attention was given to the multidisciplinary nature of part-time farming issues, the conference did not address the opportunities for meaningful cooperation among agricultural economists, geographers, and rural sociologists in addressing these issues. Given the objectives of the conference, it is difficult to understand why the experiences of some of the Far Eastern countries were not included. The conference was dominated by papers about Ontario, Canada. One is left with the uneasy feeling that not much has been learned about part-time farming outside Ontario. However, this is probably a telling sign about the current status of part-time farming research in the countries represented rather than an indication of parochialism on the part of the conference planners and hosts.

Bernard L. Erven
Ohio State University

Thurow, Lester C. *Generating Unequality: Mechanisms of Distribution in the U.S. Economy*. New York: Basic Books, 1975, xiv + 258 pp., $5.95 paper.

How does an economy generate income and wealth distributions? As early as 1848, John Stuart Mill asserted that "it is only in the backward countries of the world that increased production is still an important object; in those most advanced, what is economically needed is a better distribution" (p. 749). Distribution remained central to economic analysis until the twentieth century, when the separation of equity and efficiency focused attention on the latter. In the last decade, the study of distributional issues has once again gained intellectual respectability. *Generating Unequality* is an attempt to explain observed reality by formulating separate theories of the determinants of income and wealth.

Rejecting the marginal productivity theory of distribution as an amorphous body of assumptions embellished by ad hoc hypotheses to explain deviations between theory and reality, Thurow sets out to "construct consistent mechanisms for explaining the observed distributions of earnings and wealth" (p. xi). Since earnings and wealth are generated by different distribution mechanisms, separate distribution theories are constructed. A "job competition" model is advanced to explain the distribution of earnings, while a "random walk" theory serves to explicate the distribution of wealth. Distribution mechanisms are viewed as processes generating different "economic prizes" or outcomes under alternative sets of rules. By comparing and evaluating different sets of rules, an optimal distributional framework can be selected.

The book comprises four parts. Part I surveys the distribution of income and wealth and discusses the equity criteria against which any distribution must be assessed. Part II advances a job competition model to explain the distribution of earnings, while part III describes the determinants of the distribution of wealth. The book concludes with a discussion of the impact of discrimination on the earnings distribution and the policy implications that flow from the analysis. The appendices provide an overview of marginal productivity theory and a listing of persons with fortunes in excess of $50 million.

The book opens with an overview of changes in the distribution of personal incomes since 1947. Between 1947 and 1972, the two poorest quintiles and the richest quintile transferred 4% of their income to the fourth quintile, the upper middle class. Physical wealth is more concentrated; in 1969, the top 7.4% of the population owned about 60% of all wealth. Income and wealth distributions are, of course, meaningless without some criteria against which they can be judged. After noting that economists have neglected equity issues to focus on efficiency mechanisms, four specifications of economic equity are proposed: rely on fair or equitable rules; allow individual preferences to prescribe equity; distribute income and wealth in accordance with "merit"; and utilize distributional criteria that maximize the common good. After examining the four approaches and their shortcomings, Thurow concludes that "equity remains unspecified, . . . since any specification of equity requires substantial amounts of empirical information" (p. 50), which is unavailable.

"Deviant" labor market observations are adduced to illustrate the failure of marginal productivity theory to explain the observed distribution of earnings. The persistence of unemployment and the continued skewness in the earnings distribution despite a trend toward equalization in the distribution of human capital (education) attributes provides the foundation for a "job competition" view of the

labor market. Rather than acting to distribute existent skills, the labor market is viewed as a device for distributing training slots among workers ranked by their costs of training. Job competition finds that "individuals compete against one another for job opportunities based on their relative costs of being trained to fill whatever job is being considered" (p. 75). The distribution of jobs is determined by technology, exogenously determined wages, and the way in which training costs are shared between workers and employers. Since the wage attaches to the job rather than the individual, competition is confined to movement along a labor queue that ranks workers in terms of their relative costs of training for a particular job. Thus, the rules governing access to job slots simultaneously act to dictate the distribution of earnings.

Turning from the earnings distribution to the distribution of wealth, Thurow advances a "random walk" theory of the creation of large fortunes. Those not inheriting wealth take advantage of disequilibrium between rates of return in real and capital markets. Chronic disequilibrium in rates of return within and between industries and the tendency of industry to finance investments from retained earnings result in the divergent returns between real and financial markets (which merely transmit money from one investor to another). Individuals attain "instant wealth" by being lucky participants in the disequilibrium lottery, where equal *ex ante* returns produce unequal *ex post* returns. Since fortunes are generated in a "random walk" or lottery process, there is no inherent justification for taxing capital gains at lower rates than wage earnings. Thurow argues that capital gains should be treated as wage earnings for tax purposes. In conjunction with the abolition of the corporate income tax and the distribution of all corporate earnings to stockholders, such a policy would force firms to sell stocks and bonds to raise capital, thus restoring the "proper" linkage between real and financial markets.

A statistical theory of discrimination is advanced to explain why certain groups are excluded from job-training slots. Employers treat individuals as members of a (race or sex) group and base hiring decisions on the general characteristics ascribed to that group. While the characteristics are true, on average, for the group, "the judgements are incorrect with respect to many individuals within the group" (p. 172), denying qualified individuals entry into jobs. The elimination of statistical discrimination necessitates access to jobs that provide training: "To significantly alter the distribution of earnings, it is necessary to significantly alter the distribution of on-the-job training" (p. 191). Rather than prescribing indirect methods that alter the human capital attributes of those suffering discrimination, this model argues that guaranteed access to jobs is vital to preclude continued exclusion.

In working from the observed distributions to the forces determining the distributions of income and wealth, Thurow has generated thought-provoking models. The theory that short-run labor market adjustments occur through an altering of the required applicant background or human capital attributes helps explain the actual short-run rigidity of wages. Unfortunately, such labor market models hold only in structured labor markets. Although Thurow recognizes that "there is a continuum between wage competition and job competition and that the American economy lies somewhere between those extremes" (p. 76), attention focuses on access to and promotion within a structured labor market. In structureless labor markets, epitomized by the agricultural harvest labor market, little training is necessary, permitting wage adjustments to act as short-run equilibrating devices. Similarly, one must question the import of access to job-training slots across societies. In Europe, where apprenticeship programs are relatively uniform and widespread, do markets equilibrate with applicant qualifications or other factors? Despite reservations as to the theory's generality, Thurow has provided fresh insights into an oft-neglected area of economics.

Phillip L. Martin
University of California, Davis
Giannini Foundation Paper 464.

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Book Review Editor note: In November 1976 the Frederick Wiseman film, *Meat,* was broadcast on National Public Television. Although films have not been previously reviewed in the *Journal,* the topic and content of the film is of interest to the agricultural profession. The following is a review of the film.

Wiseman, Frederick, producer. *Meat.* Boston: Zipporah Films, 1976, 113 minutes. $125 per first screening, $62.50 subsequent screenings, $950, five-year lease.

Meat is an unusual documentary film, the tenth produced by Emmy award-winner Wiseman, whose productions include *Primate,* the 1975 study of scientific experimentation with monkeys and other primates that stirred much public anger and dismay. By stressing the macabre of livestock slaughter, one suspects that Wiseman might be seeking a similar reaction to *Meat*; however, the lack of human resemblance to a steer or lamb makes empathy difficult.

This is the beef and lamb industry, from ranch through feedlot, slaughter, and packing to "ungraded goosenecks in combos," told in a two-hour black-and-white film with no narration. Wiseman

lets the sounds do the talking, including the bawling of cattle, the auctioneer's banter, salesmen making deals in their peculiar jargon, the mechanized sounds of a meat plant, and a fixation on the sounds of diesel truck engines. In a sense it is the story of the assembly line in reverse, beginning with the completed product and ending with the parts. It was not produced as an educational film, yet it is being promoted as one. This review examines that potential.

Filming took place at Monfort's feedlot and packing plant in Greeley, Colorado. Thus, it shows a "typical" feedlot of some 100,000 head capacity and a packing plant handling 10,000 head or so per week—not the average processing or farmlot feeding operation, but nonetheless representative of those 200 or so largest feedlots that currently account for over a third of all cattle feeding. As such, it documents a closely orchestrated production-processing system for meat that most people seldom if ever have the opportunity to observe first hand, yet one that is steadily becoming representative of this industry.

In quick succession, cattle are rounded up on the ranch, put on the auction block, trucked, vaccinated, disinfected, penned, fattened, weighed, trucked, penned, stunned, hoisted by the hooves, and slit at the throat. Poor husbandry practices are realistically portrayed in all livestock handling scenes. Then, in an extensive sequence of slaughter and processing, cattle are beheaded, and the heads are processed in close-up detail. Cattle are eviscerated, skinned, split, sawed into sections, cut into pieces, mechanically tenderized, ground into patties, wrapped, boxed, and shipped. The sequence is repeated for lambs, with shearing thrown in and the auction left out. A disproportionate amount of time is spent in the packing plant on relatively insignificant operations. This makes it difficult to grasp the time dimension involved in total animal and meat production, processing, and distribution. Judging by the time allocation in the film, slaughtering and processing is roughly three times as important as are all livestock enterprises combined. The lack of narration does not help eliminate this misconception.

Some insightful scenes of the management process are included. Wholesale trading in meat, procuring feeder cattle, dealing with a slow-paying customer, and a staff meeting where department heads coordinate related activities such as feeder cattle purchases, feedlot operations, slaughtering and packing, sales, and merchandising are interesting sequences. Particularly well done is a session between labor and management, with management implementing job redefinitions despite the protests of the union representatives. This sequence is particularly notable in that, as is true throughout the film, the people (as well as the animals) appear to be totally unaware that they are being filmed.

Overall, the film captures much of the complexity involved in coordinating livestock feeding, slaughtering, and meat packing. This, combined with the opportunity to see the processes involved on a large scale and to observe labor and management in their normal and unheroic routines, are the points to recommend its use for educational purposes. As such, it could be useful to classroom teachers relative to subjects such as the economics of the livestock/meat industry and meat processing and to extension educators working with livestock producers and perhaps consumers. The lack of narration should prove a benefit to educators, as the missing explanation of what is being seen tends to stimulate questions and thus discussion.

However, it has at least two major limitations for educational purposes: excessive length (involving much of little significance) and high cost. Two hours is both too long for most educational uses and much longer than needed to demonstrate the relevant points. Much of the length is due to excessive overemphasis on aspects of livestock handling that suggest cruelty and on aspects of processing that appear gruesome, such as the five-minute sequence on processing cattle heads, repeated for lamb heads. While such disproportionate coverage may make for some social commentary (unperceived by these reviewers), it adds unnecessarily to length. On cost, we have no benefit-cost ratio to offer. But, it is difficult to imagine an educational situation where the $125 initial screening fee is available, much less justified. We believe the film could benefit from a sharp editing job in terms of its usefulness to educators. It could easily be reduced in length to 30 to 40 minutes total, without losing much but its excesses and gruesomeness. If the cost was reduced proportionately, it could justify consideration by educators.

As it is, if you can catch it on your local television station, it beats watching *The $25,000 Pyramid.*

Dennis R. Henderson and Bobby D. VanStavern
Ohio State University

Books Received

Arndt, Thomas M., Dana G. Dalrymple, and Vernon W. Ruttan. *Resource Allocation and Productivity in National and International Agricultural Research.* Minneapolis: University of Minnesota Press, 1977, xxviii + 617 pp., $25.00.

Bender, Filmore E., Amihud Kramer, and Gerald Kahan. *Systems Analysis for the Food Industry.* Westport, Conn.: AVI Publishing Co., 1976, ix + 468 pp., $45.00, $23.00 paper.

Betts, Edwin Morris. *Thomas Jefferson's Farm Book.* Charlottesville: University Press of Virginia, 1976, xxiv + 552 pp., $20.00.

Bodwell, C. E. *Evaluation of Proteins for Humans.* Westport, Conn.: AVI Publishing Co., 1977, xvi + 327 pp., $35.00.

Briggs, Vernon M., Jr., Walter Fogel, and Fred H. Schmidt. *The Chicano Worker.* Austin: University of Texas Press, 1977, xv + 129 pp., $9.50.

Catsimpoolas, Nicholas. *Immunological Aspects of Foods.* Westport, Conn.: AVI Publishing Co., 1977, viii + 400 pp., $34.00.

Clawson, Marion. *Man, Land, and the Forest Environment.* Seattle: University of Washington Press, 1977, xi + 72 pp., $6.95.

Cohen, Jacob. *Special Bibliography in Monetary Economics and Finance.* New York: Gordon and Breach Science Publishers, 1976, xiii + 200 pp., $40.00.

Davey, Brian, T. E. Josling, and Alister McFarquhar. *Agriculture and the State.* London: Trade Policy Research Centre, 1976, xxiii + 280 pp., $37.50.

Drache, Hiram M. *Beyond the Furrow.* Danville, Ill.: Interstate Printers & Publishers, 1976, xiv + 551 pp., $9.95.

Fortin, Yves, and Jean Poliquin. *Natural Durability and Preservation of One Hundred Tropical African Woods.* Ottawa, Canada: International Development Research Centre, 1976, 131 pp., price unknown.

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Griffin, Paul F., Ajmer Singh, Wayne Rodgers White, and Ronald L. Chatham. *Culture, Resource, and Economic Activity: An Introduction to Economic Geography.* Boston: Allyn and Bacon, 1976, ix + 515 pp., $14.95.

Hakrow, Harold G. *Food Policy for America.* New York: McGraw-Hill Book Co., 1977, x + 564 pp., price unknown.

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International Labour Organisation. *Social Security for Migrant Workers.* Geneva, Switzerland: International Labour Organisation, 1977, vii + 154 pp., $8.95.

Koepf, Herbert H., B. D. Pettersson, and Wolfgang Schaumann. *Bio-Dynamic Agriculture.* New York: Anthroposophic Press, 1976, x + 429 pp., $12.00.

Kuo, Leslie T. C. *Agriculture in the People's Republic of China: Structural Changes and Technical Transformation.* New York: Praeger Publishers, 1976, xx + 288 pp., $23.50.

Lasswell, Harold, Daniel Lerner, and John D. Montgomery. *Values and Development: Appraising Asian Experience.* Cambridge, Mass.: MIT Press, 1976, x + 291 pp., $19.95.

Levi, John. *African Agriculture: Economic Action and Reaction in Sierra Leone.* Bucks, England: Commonwealth Agricultural Bureaux, 1976, xviii + 428 pp., £5.45.

Lipton, Michael. *Why Poor People Stay Poor.* Cambridge, Mass.: Harvard University Press, 1976, 467 pp., $15.00.

Martin, Lee R., ed. *A Survey of Agricultural Economics Literature, Volume 1.* Minneapolis: University of Minnesota Press, 1977, xviii + 540 pp., $25.00.

Monyo, J. H., A. D. R. Ker, and Marilyn Campbell. *Intercropping in Semi-Arid Areas.* Ottawa, Canada: International Development Research Centre, 1976, 72 pp., $1.00.

Rae, Allan N. *Crop Management Economics.* London: Granada Publishing, 1977, xi + 525 pp., £12.50.

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Stern, Robert M., Jonathan Francis, and Bruce Schumacher. *Price Elasticities in International Trade.* Macmillan of Canada: Maclean-Hunter Press, 1976, xvi + 363 pp., $25.95.

Tressler, Donald K., and Jasper Guy Woodroof. *Food Products Formulary, Volume 3. Fruit, Vegetable and Nut Products.* Westport, Conn.: AVI Publishing Co., 1976, xi + 278 pp., price unknown.

Tyler, Gus. *Scarcity: A Critique of the American Economy.* New York: Quadrangle/The New York Times Book Co., 1976, ix + 245 pp., $8.95.

Velayudham, Shri T. K. *Marginal Farmers and Agricultural Labourers Development Agencies.* Bombay, India: Associated Advertisers & Printer, 1976, xii + 214 pp., $3.00.

Warner, James N. *Principles of Dairy Processing.* New York: Halsted Press, 1976, x + 317 pp., $7.50.

Woods, A. E., and L. W. Aurand. *Laboratory Manual in Food Chemistry.* Westport, Conn.: AVI Publishing Co., 1977, vii + 72 pp., price unknown.

Announcements

1977 Meeting Allied Social Sciences Association

The American Agricultural Economics Association will meet jointly with the Allied Social Sciences Association in New York City, 28–30 December 1977. A program will be published in the November issue of the *Journal*.

Book Review Editor

Starting with the February 1978 issue, Herbert H. Stoevener will be the book review editor. Communications about books for review and books submitted for announcement in the *Journal* should now be sent to Herbert H. Stoevener, Department of Agricultural Economics, Oregon State University, Corvallis OR 97331. All other manuscripts and editorial correspondence may be sent to the new editor, V. James Rhodes. However, revisions of manuscripts originally submitted to the current editor should be sent to Cornell University so that the entire folder can be forwarded to Professor Rhodes.

Personnel

Agricultural Development Council

Appointments: Veit Burger, former research assistant, Cornell University, is a specialist for Nepal; **Robert E. Evenson,** former Council associate, University of the Philippines at Los Banos, is with the Department of Economics, Yale University, effective Sept. 1977; **Max R. Langham,** formerly with the regional office in Singapore, is an associate, University of the Philippines at Los Banos; **Shao-er Ong,** formerly with the Department of Agricultural Economics, Michigan State University, is an associate in Bangkok, Thailand; **Vernon W. Ruttan,** Council president, formerly with the regional office in Singapore, is with the New York office; **Donald C. Taylor,** formerly with the Department of Agricultural Economics, University of Wisconsin, is an associate in Kuala Lumpur, Malaysia.

Auburn University

Retirement: J. Homer Blackstone is a professor emeritus after 31 years of service.

Cornell University

Appointments: Barry Edmonston, former assistant professor, Stanford University, is with the International Population Program; **Robert C. Nolan** is an extension associate in the Cornell Home Study Program in food industry management; **Jan Sweeney** is a visiting assistant professor, 1977–78.

University of Florida

Appointments: Jose Alvarez, Timothy D. Hewitt, formerly with the University of Tennessee, and **Bryan E. Melton,** formerly with Iowa State University, are assistant professors.
Leaves: Edna T. Loehman is on academic development leave at the Stanford Food Research Institute and the Department of Economics, University of New Mexico, Sept. 1977–June 1978.

University of Illinois

Appointments: Mack N. Leath is an associate professor; **K. E. Nelson** is an assistant professor.

Kansas State University

Appointment: Gary Vacin is the extension editor for the Kansas Cooperative Extension Service.

Resignations: Parman Green, former area extension economist, Garden City, is with the Farmers and Merchants State Bank of LaCrosse, Kansas; **Dean Parker,** former area extension economist, Concordia, is a county extension agent in Ohio.
Honor: Dale L. Fooshee of Garnett, Kansas, 1951 graduate, was named the 1977 Distinguished Agricultural Economics Alumnus.

University of Manitoba

Appointment: Edward W. Tyrchniewicz succeeds Arthur W. Wood as head, Department of Agricultural Economics.

University of Maryland

Appointment: Barbara J. Redman, Ph.D. Iowa State University, is an assistant professor of consumer economics.

University of Massachusetts

Appointments: N. E. Engel is director, Office of Policy Analysis, College of Food and Natural Resources; **John H. Foster** is chairman, Department of Food and Resource Economics.

Michigan State University

Appointment: Lindon Robison, formerly with the ERS, USDA, is an assistant professor in production economics.
Retirements: Richard Hartwig, after 27 years of service; **Henry Larzelere,** after 35 years of service.
Honor: Lester V. Manderscheid received a 1977 Distinguished Faculty Award, the highest faculty honor within the University.

University of Minnesota

Appointments: Dale W. Nordquist, M.S. University of Minnesota, is an assistant extension specialist, farm management-Farmers Home Administration; **Michael D. Petkovich,** M.S. University of Nevada, is a research specialist in economics of tourism and recreation.

University of Nebraska

Leave: Paul Gessaman, professor, is on a research assignment at the North Central Rural Development Center, Ames, Iowa, April–Sept.

North Carolina State University

Appointments: John D. Hanson, Jeffrey S. Royer, Gary F. Vocke, and **Michael K. Wohlgenant** are assistant professors of economics and business.
Retirement: Henry A. Homme, former extension associate professor.

Pennsylvania State University

Leaves: Robert F. Hutton is with the Cooperative State Research Service, Washington, D.C., through June 1978; **J. Dean Jansma** is the assistant dean for research, College of Agriculture, through June 1978.

Purdue University

Appointments: Janet S. Ayres is a community development analyst; **Peter L. Nuthall** is a visiting assistant professor in farm management; **Thomas L. Vollrath** is a temporary assistant professor on the Agency for International Development African Project.
Honor: David C. Petritz was elected to the Board of Directors of the American Forage and Grassland Council.

Rutgers—The State University

Appointment: A. Robert Koch, chairman, Department of Agricultural Economics and Marketing, is on the State Clean Air Council, New Jersey.

Stanford University

Appointments: Carl H. Gotsch, Ph.D. Harvard University, is an associate professor; **Anne Peck,** Ph.D. Stanford University, is an assistant professor.
Leave: Tetteh A. Kofi, assistant professor, is on leave, Sept. 1976–77.
Honors: Walter P. Falcon, director, Food Research Institute, was awarded the Helen Cherington Farnsworth Professorship in international agricultural policy; **Roger W. Gray,** professor, was awarded the Holbrook Working Professorship in commodity price studies.

Texas A&M University

Appointments: Richard Edwards, formerly at the University of Georgia, is an economist in agribusiness; **Bruce Gardner,** former senior staff economist, President's Council of Economic Advisors, is a professor; **Ray Owensby,** formerly with Texas Transportation Institute, is an extension economist in marketing.

U.S. Department of Agriculture

Appointment: Linley Juers is with the Inputs and Finance Program, National Economic Analysis Division, ERS.
Retirement: Arthur J. Walrath, former adjunct professor and agricultural economist, Economic Development Division, ERS, Virginia Polytechnic Institute and State University.

Washington State University

Appointments: Richard Dunford, formerly with the University of Wisconsin, and **Ronald Mittelhammer** are assistant professors.

University of Wisconsin—Madison

Appointment: Marvin B. Johnson, Ph.D. Syracuse University, is an assistant professor of public finance.
Honor: Frank Groves received the 1976 Cooperative Builder Award from the Wisconsin Federation of Cooperatives.

University of Wyoming

Appointment: Ed Bradley, Ph.D. candidate, Pennsylvania State University, is a research associate in resource economics.

Other Appointments

Mark J. Erlandson, M.S. Oregon State University, is with the Oregon State Department of Economic Development, Portland.
David A. G. Green, University College of Wales, is on sabbatical leave as professor of agricultural economics and head of the Rural Development Department, Bunda College of Agriculture, University of Malawi, Lilongwe.
Edward E. Ives, Ph.D. Oregon State University, is with the Governor's Energy Advisory Council, Austin, Texas.
Marshal Khan, Ph.D. Stanford University, is a research fellow, Economic Development Institute, University of Nigeria, Enugu.
Larry S. Robbins, M.S. University of Arkansas, is self-employed in livestock and other operations in the Northwest Arkansas area.
Thomas E. Snider is vice-president of the Charlotte Branch, Federal Reserve Bank of Richmond, North Carolina.
Harold B. Williams, M.S. University of Arkansas, is a county extension agent—agriculture, Arkansas Cooperative Extension Service, Hamburg.
Lawrence Witt received a Meritorious Honor Award for his work in the U.S. Department of State.

Obituaries

Wendell C. Binkley

Wendell C. Binkley served the University of Kentucky in the Department of Agricultural Economics from 1946 to his death on 4 December 1976.

Binkley received a B.S. in agriculture with "High Distinction" from the University of Kentucky in 1939 and an M.S. in agriculture, with a major in agricultural economics, in 1942. His doctoral work in economics was done at Vanderbilt University, 1952–53. In the areas that his professional interests centered around—cooperative marketing, agribusiness management, and youth education, he received recognition at the state, national, and international levels.

Perhaps the most rewarding to Binkley was his work with the youth of the Commonwealth of Kentucky. He developed the Kentucky Youth Seminar for high school juniors for the purpose of learning about the American private enterprise system. Several hundred Kentucky students participate annually in this nationally recognized program. State winners have made an enviable record in national competition and thus achieved recognition for themselves, Binkley, and the University.

In 1964 and 1968–69, he served as a consultant with the Ford Foundation in India. He helped develop the Vaikunth Mehta National Institute of Cooperative Management at Poona, India, which engages in management research, training, and consulting. As a member of the Delhi-based Ford Foundation's Intensive Agricultural Development Program team, he worked with cooperatives and government officials in utilizing the "package" approach to improve agricultural production and marketing.

Binkley authored numerous publications in agricultural marketing. In addition, he was a member of the Youth Education Consulting Committee of the American Institute of Cooperation and the Social Sciences Advisory Committee of the Cooperative Foundation in Chicago, Illinois, as well as a member of Alpha Zeta and Gamma Sigma Delta—agricultural honorary societies, Block and Bridle, U.K. Agribusiness Clubs, and the Methodist Church.

He is survived by his wife, Byrd Binkley, a daughter, Mrs. Lewis B. Henry, and a son, Thomas K. Binkley.

Members of the Department of Agricultural Economics, as well as a host of coworkers and friends, will miss this enthusiastic, dynamic, and compassionate colleague.

Newton Mack Penny

Newton Mack Penny, professor emeritus, University of Georgia, died on 28 January 1977 at the age of 67. Penny was born at Lakeland, Georgia, in 1909. He received his B.S.A. (1933) in agricultural economics from the University of Georgia and his M.S. (1941) and Ph.D. (1950) in agricultural economics from Cornell University.

In his early career, Penny was active in marketing research, especially in the field of dairy products and peanuts. He also contributed leadership and direction to the establishment and operation of regional research in the South. In 1957 Penny became the head of the Department of Agricultural Economics of the Georgia Experiment Station, holding this position until his retirement in August 1971. Under his guidance and encouragement, the Department grew numerically, but more importantly, it also increased in stature and influence throughout the region and nation.

Penny was a loyal and dedicated friend of agriculture and will be missed by his colleagues and friends. He is survived by his wife Evelyn of Griffin, Georgia, four children, and four grandchildren.



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LAND ECONOMICS

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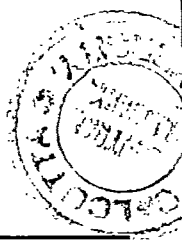
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Articles

An Equilibrium Analysis of U.S. Sugar Policy

Gordon Gemmill

U.S. sugar policy is examined in an international context by means of a spatial equilibrium model of the world sugar economy in which various trade barriers are imposed. The Sugar Act, which expired in 1974, is found to have had only a minor influence on U.S. price and a small net cost to the nation. International free trade would cause greater adjustment in the European Economic Community than in the United States. Discrimination in trade against Cuba continues to impose large costs on that country. A cartel of cane-sugar exporters would be very unlikely to succeed.

Key words: cartel, international trade, policy, spatial equilibrium, sugar, United States.

This article is concerned with the costs and benefits of alternative U.S. and international sugar policies, particularly from the U.S. viewpoint. Among the policies considered are the Sugar Program as of 1974, international free trade, unilateral free trade by the United States, and an international cartel of cane-sugar exporters. The repercussions of the U.S. embargo on Cuban sugar and the inefficiency of the international pattern of trade in sugar are also examined. The method of analysis is the simulation of the world sugar economy with a spatial-equilibrium model in which various trade barriers are imposed. Prices and quantities are calculated for a series of resulting long-run equilibria, which may be considered as average positions in a fluctuating market. The article concentrates particularly on the U.S. Sugar Program, which ended in 1974, as similar legislation to protect domestic producers continues to be discussed and the results of this research indicate that the program had a smaller impact than had previously been recognized.

The Sugar Act, as amended in 1971, had the following features (see Johnson, p. 10, for a fuller presentation): (*a*) a price objective, related to the parity index of agricultural input prices and the wholesale price index;[1] (*b*) quotas on domestic production and on both raw and refined imports designed to be consistent with the price objective; (*c*) a tariff on imports of 0.625¢ per raw pound; (*d*) a tax at wholesale on all sugar of 0.50¢ per raw pound; (*e*) small payments to producers conditional upon their keeping within their quotas; and (*f*) the setting of minimum wages to be paid to workers in the sugar industry.

From the viewpoint of avoiding low domestic prices, the Act was undoubtedly successful (figure 1). Quotas were adjusted so that the United States was not subject to the price troughs of 1955, 1961, or 1966 that occurred in the largely unregulated world free market. On the other hand, any significant decline in the rate of expansion of world production, such as occurred in 1950–51, 1957, 1963, and 1974, resulted in increased prices in both the world and U.S. markets. Price behavior in the United States was therefore similar to that in the free market but truncated at the lower end.

World sugar production in 1974 was 78.7 million tons of which only 21.7 million tons were traded.[2] The free market accounted for 10.7 million tons, U.S. imports for 5.2 million tons, and other bilateral arrangements for the

Gordon Gemmill is a lecturer in economics, Wye College, London University.

The author is grateful for financial assistance from Michigan State University, the U.S. Department of Agriculture, and the U.S. Department of the Treasury. Helpful comments from two anonymous reviewers are acknowledged.

[1] Stated formally, it is

$$POB_t = \frac{PSUG_o\,(PARINDEX + WPI)_t}{(PARINDEX + WPI)_o},$$

where *POB* is the price objective, *PSUG* is the price of sugar, *PARINDEX* is the parity index of agricultural input prices (1967 = 100), *WPI* is the wholesale price index (1967 = 100), *o* denotes 1 Sept. 1970 to 31 Aug. 1971, and *t* denotes current time period.

[2] All tons are metric and in raw value (92 parts raw equals 100 parts refined). The data came from the International Sugar Organisation.

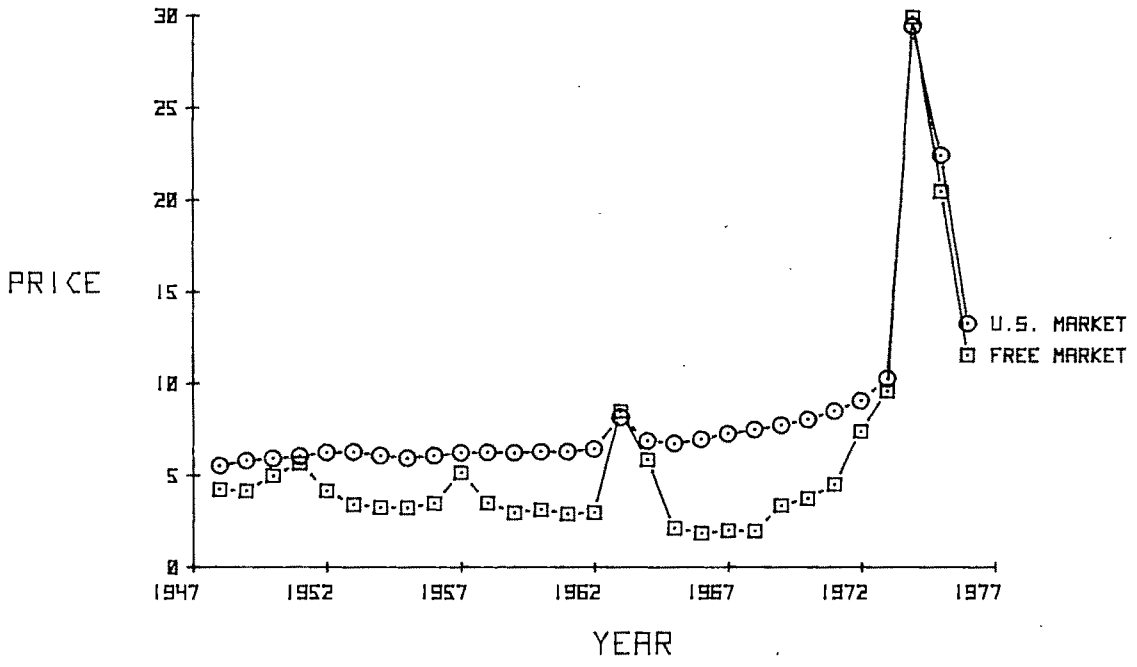


Figure 1. Prices in U.S. and free markets, 1948–76 (U.S. cents per raw pound)

remaining 5.8 million tons. When the Sugar Program ended in January 1975, the United States became the largest importer operating in the free market and, as shall be seen, the long-run price on that market may be expected to be higher as a consequence.

Analytic Framework

This research combines and extends the approaches of Johnson and Bates. Johnson uses a range of premia (that is, the difference between the U.S. protected and estimated unprotected prices) in order to judge the likely cost of the Sugar Program. At premia of 1.5¢, 2.0¢, and 2.5¢ per raw pound in 1972, the cost to consumers and taxpayers is estimated to be $502, $616, and $730 million, respectively. Assuming relatively inelastic domestic supply, the benefit of the program to U.S. farmers is estimated to be $101 million at most. Johnson estimates transfers to quota-holding foreign countries to be about $198 million. He concludes that the apparatus of the program should be removed, as it was clearly inefficient in terms of resource allocation, but suggests that it might possibly be replaced by a system of deficiency payments in order to avoid depressed prices. Earlier work along similar lines by Snape reached similar conclusions concerning the inefficiency of the protection and taxation of sugar for several wealthy nations, including the United States.

The work of Bates (also reported by Bates and Schmitz) is mainly concerned with the inefficiencies created by the special arrangements under which sugar was traded, such as the Sugar Act, and particularly with the additional inefficiency resulting from the cessation of trade by the United States with Cuba in 1960. The approach uses spatial equilibrium for a thirty-three-region world together with linear supply and demand functions. Two equilibria were computed, one with international free trade and the other with free trade except for the exclusion of Cuban sugar from the United States. Compared with actual 1959 prices, competitive free-trade prices were found to be substantially different, that of the United States being 19% lower. However, the cost of excluding Cuba from the U.S. market was an increase of only 2% in the U.S. price.

Both of these studies have distinct limitations that the present work has attempted to overcome. Johnson makes informed guesses concerning supply and demand, whereas great attention is directed in the present research to estimating supply and demand functions. Bates estimates simple linear supply functions, whereas more complicated forms, in some cases implying irreversible responses,

are used in this work. Bates takes no account of the controls on production and trade in the United States and other markets. The current work computes equilibria in which the whole set of existing trade distortions including tariffs, variable levies, and quotas is imbedded. Despite the pioneering work of Bawden, very few models have specifically incorporated the distortions on international trade. An exception is the work of Zusman, Melamed, and Katzir on oranges in Europe. The extreme case of free trade may be of interest, but it has very little relevance to policy making. Beginning with the case of fully distorted trade, the serial relaxation of the distortions in this model allows the costs and benefits of protection to be carefully evaluated.

In the model the world was divided into seventy-five regions, each based on a single port. Sixty-eight of the regions have supply functions, and all seventy-five have demand functions. The United States was divided into five regions based on the ports of New Orleans, New York, San Francisco, Honolulu, and San Juan. Because of the concentration in this article on U.S. policy, the five regions were further disaggregated into eight (four beet-producing, two mainland cane, Hawaii, and Puerto Rico) in presenting the results. The supply and demand equations for the whole model are too numerous to be listed here and may be reviewed in Gemmill (chaps. 3 through 7).

The model is quite simple and may be stated as follows. Let there be m producing and n consuming regions, subscript i always denoting a producing region and subscript j a consuming region, then Q_j^D is the quantity of raw sugar demanded in the jth region, Q_i^S is the quantity of raw sugar supplied by the ith region, P is the wholesale price of raw sugar, q_{ij} is the shipment of raw sugar from region i to region j, and G_{ij} the cost of shipment, including trade barriers, from region i to region j.

Demand relations for each consuming region are

$$(1) \quad Q_j^D = Q_j^D(P_j) \text{ for } j = 1, 2, \ldots, n.$$

Supply relations for each producing region are

$$(2) \quad Q_i^S = Q_i^S(P_i) \text{ for } i = 1, 2, \ldots, m.$$

Total quantity demanded in equilibrium equals the sum of all shipments, or

$$(3) \quad Q_j^D = \sum_i q_{ij} \text{ for } j = 1, 2, \ldots, n.$$

Total quantity supplied in equilibrium equals the sum of all shipments, or

$$(4) \quad Q_i^S = \sum_j q_{ij} \text{ for } i = 1, 2, \ldots, m.$$

Shipments cannot be negative, or

$$(5) \quad q_{ij} \geq 0 \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n.$$

At equilibrium the prices in any two regions cannot differ by more than the transfer cost per unit, or

$$(6) \quad P_j - G_{ij} - P_i \leq 0 \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n.$$

At equilibrium the sum of transfer expenditures is exactly balanced by the sum of price differences times quantities shipped for all regions, or

$$(7) \quad \sum_i \sum_j \{(P_j - G_{ij} - P_i)q_{ij}\} = 0.$$

The solution gives quantities produced and consumed in each region as well as intersectoral trade and the domestic price in each region. All prices are converted to the wholesale level for solution, and all known taxes on consumption are incorporated into the G_{ij} term of equations (6) and (7). All prices are in 1974 dollars, and technology, population, and income are fixed at estimated 1974 levels. Solution is by means of an adaptation of the King and Ho reactive programming algorithm.

Five policy experiments of particular interest to the United States were conducted: (*a*) Sugar Act as of 1974 in operation and all other countries having their 1974 policies; (*b*) free (i.e., competitive) trade by all countries, except for the imposition of taxes on consumption; (*c*) unilateral free trade by the United States, including the importation of Cuban sugar, all other countries continuing their previous policies; (*d*) free trade by the United States as in (*c*), but Cuban sugar not allowed entry to the United States (essentially the current situation); and (*e*) cartel of cane-sugar exporters imposes a 10¢ per pound export tax on raw sugar, otherwise policies as in 1974.

Results

U.S. Domestic Production

Table 1 gives the computed outputs under the alternative policies as well as the New York domestic and free market prices. Actual pro-

Table 1. Equilibrium U.S. Domestic Production and New York Prices under Alternative Policies

Region	Actual[a] 1974	(a) Full Protection	(b) Free Trade	(c) U.S. Free Trade	(d) U.S. Free Trade Excluding Cuba	(e) 10¢ Cartel
	1,000 Metric Tons Raw Value					
Beet[b]						
I	662	616	565	552	571	733
II	763	665	605	590	612	803
III	470	723	644	499	574	991
IV	750	1,197	1,061	812	938	1,671
Subtotal	2,645	3,201	2,875	2,453	2,695	4,198
Cane						
Florida	728	889	591	460	572	1,058
Hawaii	944	944	914	827	862	1,052
Louisiana	539	691	610	582	607	736
Puerto Rico	263	185	165	171	165	239
Texas	67	77	59	51	58	89
Subtotal	2,541	2,786	2,339	2,091	2,264	3,174
Total	5,186	5,987 (100)	5,214 (87)	4,544 (76)	4,959 (83)	7,372 (123)
			New York Price (¢/Raw Pound)			
U.S. domestic	29.50	11.89	10.72	10.33	10.83	14.48
World free market	29.99	7.76	10.85	10.23	10.25	13.77

[a] Source: USDA, with relative sugar content per ton assumed to be as in 1973.
[b] Definition of regions: I: Michigan, Minnesota, N. Dakota, Ohio; II: Colorado, Kansas, Montana, Nebraska, Texas, Wyoming; III: Idaho, Oregon, Utah, Washington; IV: Arizona, California, New Mexico.

duction and prices for 1974 are included on the left-hand side of the table, but valid comparisons may only be made between the computed, long-run equilibria. Comparisons with the actual situation in 1974 are particularly misleading, as in that year the market was far from a long-run equilibrium—production was at its lowest for twelve years and prices were at their highest recorded level.

Policy (*a*) is that which existed in 1974 and is used as a benchmark for comparisons. In the long run a switch to free trade by all nations, as exemplified by policy (*b*), implies a 13% decline in U.S. sugar production. A switch to free trade by the United States alone (policy (*c*)) implies a 24% decline in U.S. production, but if Cuban sugar is excluded (policy (*d*)) the decline is limited to 17%. This 17% decline is what is therefore predicted to occur under current policy. A cartel of cane-sugar exporters imposing a 10¢ export tax (policy (*e*)) would, conversely, result in an expansion of 23% in U.S. production.

These outcomes reflect the price equilibria between domestic import demand and foreign export supply under different policies. The key to understanding them lies in the underlying supply functions. It would be usual to assume that foreign export supply is highly price elastic and that domestic U.S. supply is inelastic. Contrary to this, the weighted average elasticities for the United States, which were estimated in the original research and incorporated here, are 1.74 for beet and 1.57 for cane, while export supply to the United States is less elastic. As a result, when the United States ends protection, the world free market price is raised by more than the U.S. price is lowered. For example, a switch from protection under the Sugar Act (policy (*a*)) to current policy (*d*) raises the free market price by 2.49¢ (32%) and reduces U.S. price by 1.06¢ (9%). With the United States buying there, prices of the order of 2¢ per pound, which occurred in the free market in 1966–68, are unlikely to be repeated.

The geographical distribution of U.S. contraction or expansion depends on the elasticities of supply in the different regions. Most of the adjustment occurs in beet regions III and IV (which include the Pacific Northwest, Utah, and California) and in Florida. For the two beet regions, the contraction of 31% under the most extreme circumstances (i.e., under U.S. unilateral free trade) is less than that which actually occurred in 1974. For Florida, under such circumstances the computed contraction of 48% may seem unrealistically large, but it refers to the long run in which all inputs (including capital in cane and mills) are vari-

able. No attempt is made to adjust for asset fixity in the U.S. cane industry. Under current policy, (*d*), the discrimination against Cuban sugar reduces the contractions in the responsive regions to 21% for beet regions III and IV and 36% for Florida.

The repercussions of alternative policies on the major sugar producers of the world are remarkably muted (table 2). World production is not significantly altered by any policy except a 10¢ tax on exports by all cane-sugar exporters (policy (*e*)), following which a decline of 4% occurs relative to the 1974 set of policies (policy (*a*)). The ease of adjustment of beet-sugar production throughout the world dampens any tendency to greater changes in total output. Supplies from Brazil and Cuba are hardly affected by the liberalization of trade in the model. The USSR is also unresponsive, except under the imposition of a cartel that would lead to a 16% increase in Soviet production. The European Economic Community (EEC) would face an estimated 23% contraction under free trade, as compared with the 13% contraction in the United States under similar circumstances. This reflects the very high degree of current protection in the EEC.

The Direction of U.S. Trade

In 1974 net imports were 50% of U.S. consumption as compared with 45% in 1973. The simulated equilibrium with 1974 policy (see policy (*a*) in table 3) fixes imports by quota at 44% of consumption. International free trade (policy (*b*)) is then estimated to result in Cuba exporting 5.8 million tons to the United States. This figure is inflated by the peculiar equilibrium in which the United States itself exports 1.4 million tons, but undoubtedly Cuba is the natural supplier for the U.S. market. Unilateral free trade by the United States (policy (*c*)) would also be of immense benefit to Cuba, with 3 million tons now coming into the United States from there and another 3.2 million tons being imported from elsewhere. U.S. free trade with discrimination against Cuba, the 1976 situation (policy (*d*)), produces a widely dispersed pattern of trade. Brazil, the Dominican Republic, Mexico, and Peru now become important. Curiously, and perhaps unrealistically since it produces refined sugar, Poland exports 0.4 million tons to the United States in this case. The Philippines, Australia, China-Taiwan, and South Africa are suppliers for which the United States is not a natural market, and hence they do not appear except under the old Sugar Act with its quotas (policy (*a*)). Under the three regimes of freer trade (policies (*b*), (*c*), and (*d*)), imports are 52%, 58%, and 54% of consumption, respectively, as compared with the 44% under the 1974 policy. A 10¢ tax on exports by the cane-sugar exporters (policy (*e*)), equivalent to a sugar cartel, reduces U.S. imports to 32% of consumption. Under this policy Cuba remains an exporter of 1.8 million tons to the United States, but her domestic price is reduced to a mere 2.73¢ per pound (see table 4), and the USSR exports 1.3 million tons to the United States as she is not part of the cartel. U.S. domestic production, as previously noted, is greatly expanded in this case.

The cost to Cuba of the continuing U.S. trade embargo may be assessed from table 4. The value of Cuban sugar production under the Sugar Program of 1974 is estimated in the model to be $924.5 million. Freedom to trade with the United States (policy (*c*)) leads to a gain of $334.5 million or 36% of this value. Given the current policy situation as approximated by policy (*d*), Cuba gains $281.9 million or 29% from renewed access to the U.S. market. At the extreme, universal free trade (policy (*b*)) holds the possibility of a $420.7 million

Table 2. Equilibrium Production of World Sugar under Alternative Policies

Region or Country	Actual 1974	(a) Full Protection	(b) Free Trade	(c) U.S. Free Trade	(d) U.S. Free Trade Excluding Cuba	(e) 10¢ Cartel
	1,000 Metric Tons Raw Value					
Brazil	6,931	6,242	6,218	6,268	6,237	5,366
Cuba	5,926	6,240	6,220	6,214	6,199	5,035
EEC	9,237	9,303	8,112	9,305	9,294	10,223
USSR	8,526	10,426	11,575	10,764	10,734	12,083
U.S.	5,399	5,987	5,214	4,544	4,959	7,372
World total	78,699	78,535 (100)	77,575 (99)	77,818 (99)	78,123 (99)	76,245 (96)

Table 3. Equilibrium Sources of U.S. Sugar under Alternative Policies

Region or Country	Actual Shipment in 1974	(a) Full Protection	(b) Free Trade	(c) U.S. Free Trade	(d) U.S. Free Trade Excluding Cuba	(e) 10¢ Cartel
	1,000 Metric Tons Raw Value					
Domestic						
U.S. beet (I, II)	2,922	1,152	1,170	1,160	1,183	1,536
U.S. beet (III, IV)		1,920	1,706	1,431	1,512	2,662
U.S. cane	1,268	1,657	732[a]	1,153	1,237	1,883
Hawaii	946	944	35[b]	849	862	698
Puerto Rico	263	185	136[c]	173	165	240
Total domestic	5,399	5,987	3,779	4,544	4,959	7,372
Imports						
Argentina	100	77	0	0	286	0
Australia	219	343	0	0	0	0
Barbados	34	2	0	35	36	54
Bolivia and Chile	5	6	0	0	0	0
Brazil	711	597	0	0	1,719	0
China-Taiwan	82	80	0	0	0	0
Colombia	95	69	288	270	266	0
Cuba	0	0	5,765	3,028	0	1,823
Dominican Republic	746	671	0	378	792	310
Fiji	42	41	0	62	237	0
Guatemala	87	56	89	83	84	0
Guyana	106	29	0	91	93	141
India	77	73	0	0	0	0
Jamaica	89	0	0	211	235	125
Mauritius	41	41	0	0	0	0
Mexico	488	578	641	818	432	0
Nicaragua	48	70	121	108	109	0
Peru	443	370	41	342	342	0
Philippines	1,336	1,308	0	0	0	0
Poland	0	0	0	0	413	0
South Africa	100	97	0	0	0	0
Thailand	24	17	0	0	0	0
Trinidad and Tobago	28	9	0	83	87	0
USSR	0	0	0	0	0	1,346
Venezuela	0	28	0	108	106	0
Central America	291	289	162	64	94	0
Paraguay and Uruguay	8	6	0	0	0	0
South Central Africa	50	25	0	0	0	0
Total imports	5,250	4,753	7,107	6,354	5,949	3,446
Net imports as % consumption	49	44	52	58	54	32
Total	10,649	10,740	10,886	10,898	10,908	10,818

[a] 530,000 tons exported to Pakistan.
[b] 879,000 tons exported to Japan.
[c] 29,000 tons exported to North Africa.

gain for Cuba. Finally, under the cartel policy (*e*), the value of Cuban sugar rises by $385.6 million above its 1974 equilibrium value, assuming that Cuba's special access to the Communist market continues.

The international transportation of sugar is estimated to cost $1,059 million under the 1974 set of policies (see policy (*a*) in table 5). Universal free trade reduces this cost to $819 million, a 23% saving, which is a measure of the

Table 4. Price, Output, and Value of Cuban Sugar under Alternative Policies

	(a) Full Protection	(b) Free Trade	(c) U.S. Free Trade	(d) U.S. Free Trade Excluding Cuba	(e) 10¢ Cartel
Havana price (¢/pound)	6.72	9.81	9.19	7.15	2.73
Production (1,000 metric tons)	6,240	6,220	6,214	6,199	5,035
Value ($ million)	924.5	1,345.2	1,259.0	977.1	1,310.1[a]

[a] Includes $1,007.1 million in export-tax revenue.

Table 5. International Costs of Transporting Sugar under Alternative Policies

(a) Full Protection	(b) Free Trade	(c) U.S. Free Trade	(d) U.S. Free Trade Excluding Cuba	(e) 10¢ Cartel
		$ Million		
1,059	819	888	958	n.a.
(100)	(77)	(84)	(90)	

inefficiency of trade in 1974. Two contributors to this inefficiency are the quotas of the Sugar Act and the embargo on Cuban sugar. The ending of the Sugar Act, but with the embargo continuing as at present, saves $101 million (10%). The ending of the embargo (policy (*c*)) leads to a further saving of $70 million. Transportation costs are important for Cuba because other markets are distant (e.g., USSR and Japan). It is not only necessary to bar Cuban exports to the United States in computing some of the equilibria but also to prevent the "laundering" of Cuban sugar via the Dominican Republic, Mexico, and Colombia.

These results reinforce one's qualitative expectation that the pattern of trade in sugar is economically inefficient. The gains to Cuba from access to the U.S. market are large, mainly stemming from the large transportation costs that she now has to bear. The effect on U.S. price of excluding Cuban sugar is estimated to be an additional 0.5¢ per pound (table 2), equivalent to 5%, whereas in Cuba the effect is a loss of 2.04¢ per pound (table 4), equivalent to 22%. These results may be compared with those of Bates, who estimates a 2% premium in U.S. price for 1959 if Cuban sugar were excluded, but less than a 1% decline in the Cuban price. The present results suggest that the U.S. ability to "hurt" Cuba is much larger than previously recognized.

Welfare and Policy Implications

Domestic and International Repercussions of U.S. Policy

Thus far only production and price effects have been considered. To obtain a more general indication of welfare, changes in economic surplus are measured, assuming the income effect of price changes to be zero. The limitations of such a procedure are well known but are not considered so extreme as to invalidate this exercise entirely (see Currie, Murphy, and Schmitz for a review).

The world was divided into four segments, each of which is affected differently by U.S. policy. There are the United States, countries that held quotas under the Sugar Act, Cuba, and the rest of the world. The single change in policy to be considered is the switch to nondiscriminatory free trade by the United States (policy (*c*)) from the 1974 protection under the Sugar Act (policy (*a*)).

Table 6 summarizes the impact of no U.S. protection on these groups in terms of producers' and consumers' surplus and government revenue. From the viewpoint of the United States, the Sugar Act is estimated to have had a net cost of only $33 million, comprising costs to consumers of $330 million, gains to producers of $230 million, and government tariff revenue of $67 million. Johnson, by contrast, estimates a median consumer cost of $616 million and a transfer to producers of only $100 million, leading to a net domestic cost of $516 million. Johnson's figures include the effect of the 0.50¢ per pound wholesale tax on sugar and conditional payments to producers (of less than 1.5¢ per pound), which are minor additional influences.

The present estimates suggest that Johnson greatly overstates the net cost of U.S. protection, mainly because he assumes a less elastic supply and a more elastic demand than are estimated for the present model. Considering the viewpoint of quota holders, the net value of their premium from quotas for the U.S. market under the Sugar Act is estimated to be $177 million, which they lose under U.S. free trade. The gross premium of $377 million is adjusted by changes in producers' and consumers' surplus due to alterations in the terms of trade to reach the net figure. However, Cuba gains $314 million under the assumption of its sugar entering the United States, mainly due to the saving of transportation costs already discussed. If Cuba's sugar is kept out, as at present, part of the $177 million loss of quota holders will be offset. Finally, the rest of the world loses under U.S. free trade by $191 million relative to the situation under the Sugar Act. This results from the rise in free market price, causing greater losses to con-

Table 6. Welfare Impact of U.S. Free Trade

Group	Change in Producers' Surplus	Change in Consumers' Surplus	Change in Government Revenue	Total Change
		$ Million		
U.S.	−230	330	−67	33
	(−100)[a]	(616)[a]		(516)[a]
Quota holders	568	−368	−377	−177
				(−198)[a]
Cuba	338	−25	0	314
Rest of world	537	−728	0	−191
Total	1,213	−791	−444	−21

[a] Figures in parentheses are the median estimates of Johnson.

sumers than gains to producers. The analysis leads to the conclusion that the "public interest" in the Sugar Act should be judged on the desirability of (*a*) taking $330 million of income from consumers to bolster the income of producers in the United States by $230 million and of government by $67 million, (b) avoiding low prices in the interest of producers, and (*c*) distorting the pattern of trade in favor of "certain friendly countries."

Protection Reconsidered

(This subject is discussed in Jesse et al.) These results may be set in the broader context of a theory of protection. The objectives of protection are really twofold: to maintain a level of self-sufficiency in the long run above the freemarket level, and to avoid extremes of high and low prices that occur in the short run. The effectiveness of alternative instruments in achieving these two objectives is considered.

The first or long-run objective requires the limitation of imports either directly via quotas, tariffs, or variable levies or indirectly via subsidies to domestic producers. Subsidies do not lead to an increase in the price of sugar and hence may be shown to be economically more efficient than other policies. To give protection equivalent to that of the Sugar Act would require a subsidy of 4.13¢ per pound, raising the U.S. price to 11.89¢ and lowering the free market price to 7.76¢. The cost in direct taxation would be $545 million, too large and visible a sum to be easily accepted. Of the other import-limiting policies, variable levies and quotas have the advantage, as compared with tariffs, of achieving a greater smoothing of short-run price. Both perfectly avoid the occurrence of low prices and do not exacerbate high prices. By contrast a tariff, whether specific or *ad valorem*, is less flexible in avoiding low prices (hence its demise as the major instrument for U.S. sugar policy in 1934) and merely increases high prices.

The second or short-run objective of smoothing price has already been introduced with reference to import-limiting policies. Quotas or variable levies, which passed the test of avoiding low prices, do not protect consumers from high prices. Three policies that could achieve such protection are buffer stocks, consumer subsidies, and pooled pricing. All such policies of domestic stabilization also destabilize the international market, limiting their own effectiveness. The first alternative, buffer stocks, requires that the U.S. market be separated from the free market by a quota system so that the release of sugar can have an impact in the United States. Given a price elasticity of the order of −0.03, a 1% change in quantity would induce a change in price of 33%; hence, the stocks need not be very large in relation to total consumption. The second alternative, consumer subsidies, if directly applied are not likely to be politically acceptable. However, such subsidization could be achieved through the imposition of negative variable levies or bonuses to quota suppliers. During the period of high prices from 1974 to 1975, such negative variable levies were used quite effectively by the EEC. The third alternative, pooled pricing, was used prior to 1973 by the United States in relation to oil. The consumer pays the weighted average of a regulated domestic and a fluctuating international price. It could be used in conjunction with quotas. Somewhat similarly, pooled pricing could be effected under a policy of producer subsidies by making such subsidies negative (i.e., taxes) to the amount by which free market prices exceed some price objective.

This inventory of policies indicates that two instruments are needed to achieve two objectives, just as the work of Tinbergen suggests. Producer subsidies, quotas, or variable levies, as long-run instruments, need to be combined with consumer subsidies, buffer stocks, or pooled pricing as short-run instruments. A third objective, that of maximizing U.S. revenue, may now be used to further sort the instruments. Under the Sugar Act, a potential revenue of $377 million passed to quota-holding foreigners rather than to the U.S. Treasury (table 5). Variable levies or auctioned quotas would capture these transfer payments for the United States, thus achieving protection at the level of the Sugar Act with a Pareto-better situation for the United States.

Finally, any review of policy must include the probable impact of a new International Sugar Agreement. The U.S. interest in such an agreement would be directed to the short-run smoothing of price. The interest of the major exporting nations would be in smoothing the short-run and raising the long-run price, while assuring their access to the U.S. market. The limited possibility of raising long-run price by forming a cartel has already been demonstrated, and an international meeting that includes both exporters and importers is not likely to agree to any but the smallest rise in long-run price. Hence, the role of an International Sugar Agreement is limited to the smoothing of short-run price. The only policy that might be mutually agreeable and have an impact is a commitment to free trade by all parties. The exporters would gain assured access to the U.S. market, avoiding low prices. The United States would gain by the avoidance of high prices if such a commitment reduced uncertainty and hence smoothed the cyclical supply of international sugar.

Summary and Conclusions

This article has empirically examined the long-run effects of a number of U.S. and international sugar policies and has discussed the implications for short-run stabilization of some further alternatives. Currently, the United States pursues free trade but with a continuing ban on Cuban sugar.[3] Under these circumstances, price and output are estimated to be in the long run 9% and 17% lower, respectively, than under the protection afforded until 1975 by the Sugar Act. This impact is less than might have been expected due to the large effect of the United States on its terms of trade. The cost to U.S. consumers of not having Cuban sugar is estimated to be 0.5¢ per pound or $97 million, while the repercussion for Cuba is a loss of 2.04¢ per pound or $272 million.

The ease of substitution of beet sugar for cane sugar ensures a remarkably constant world output of sugar under all policies. Even if cane-sugar exporters imposed a 10¢ per pound tax on exports, world production was estimated to decline by only 4%. However, the pattern of trade in sugar is inefficient, and free trade would save an estimated $139 million (16%) in transportation costs relative to current policies.

The net cost to the United States of the Sugar Act, as compared with free trade by the United States, was estimated to be only $33 million per annum. Whether such protection is in the public interest hinges upon the desirability of transferring income from consumers to producers rather than upon the net costs to the United States. It is possible to devise policies based on variable levies or auctioned quotas that give protection equivalent to that of the Act but that capture the $377 million that was previously transferred to foreign suppliers. Assuming the objectives of protection are to raise the long-run and to smooth the short-run prices, two kinds of instruments are needed, one to limit imports and the other to smooth prices. Any short-run stabilization of the U.S. market would tend to destabilize the world free market, thus complicating its own task. The simplest stabilization policy might be international free trade, which could be negotiated under the auspices of a new International Sugar Agreement.

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[3] Except for a small tariff of 0.625¢ per pound, raised to 1.875¢ in September 1976.

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Devaluation, Foreign Trade Controls, and Domestic Wheat Prices

Paul R. Johnson, Thomas Grennes, and Marie Thursby

The 1970s have seen sharp fluctuations in grain prices. Several plausible explanations for the unusual severity of these ups and downs have been advanced, including devaluation of the dollar for the upswing in 1972–74. U.S. wheat prices for the year of highest prices, 1973–74, are examined. A trade model that distinguishes wheat by country of origin is used to analyze various events in that year. It is concluded that insulating trade policies by wheat exporters and importers had the largest impact on U.S. wheat prices.

Key words: devaluation, land prices, trade controls, transport costs, wheat prices.

An insightful paper by Schuh called attention to the relationship between currency markets and agricultural product and factor markets.[1] He argues that overvaluation of the dollar prior to 1971 depressed the prices of U.S. agricultural products and advances the hypothesis that the subsequent devaluation of the dollar was responsible for an important part of the increase in agricultural prices in 1973–74.[2] This article is an attempt to test that hypothesis by considering the exchange rate and other explanatory variables that should also affect agricultural prices and compare their relative importance. The variables selected from orthodox trade theory are tariffs, export taxes, and transport costs.

The evidence fails to support the hypothesis that devaluation had a larger effect on prices than any of the other variables taken separately. This conclusion stems largely from looking at a particular market—U.S. wheat exports. In value terms, wheat is the most important agricultural product exported by the United States. Since the export markets for U.S. agricultural products have been highly volatile since 1970, data for this period should be helpful in identifying sources of price changes. We concentrate on the substantial price increase in the crop year 1973–74 when wheat prices exceeded $6 per bushel ($220 per metric ton). Specifically, how much of the observed increase in the domestic price was attributable to dollar devaluation and how much to tariff policy of the European Economic Community (EEC), trade controls by Canada, Australia, and Japan, and policy-distorted ocean freight rates?

Theoretical considerations would lead one to expect that dollar devaluation, tariff reductions by the EEC and Japan, and export restrictions by Canada and Australia would all shift demand toward U.S. wheat and raise its price in the United States. Higher transport costs from the United States to its major markets would lower the U.S. wheat price. In fact, the above is an accurate description of the actual policies that were followed by various nations in 1973–74.

Paul R. Johnson is a professor and Thomas Grennes is an assistant professor, Department of Economics and Business, North Carolina State University, and Marie Thursby is an assistant professor of economics, Syracuse University.

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[1] Interest in this relationship is not new, having been discussed by Adam Smith in his chapters "Of the Rent of Land" and "Of Bounties." He considers the effects of devaluation (pp. 194–99) and export subsidies (book IV, chap. V), although his discussion is marred by emphasizing "the great and essential difference which nature has established between corn and almost every other sort of goods" (p. 482). In addition, the effect of the 1933 devaluation of the dollar on prices of export crops was investigated in a series of papers by Davis, Rowe, and Richards published by the Brookings Institution and by Timoshenko at the Food Research Institute. These studies are summarized by Benedict, who concludes that the price effect of the devaluation "was small or negligible for wheat" (pp. 298–99).

[2] Schuh states: "If this interpretation is correct, an important share of the rise in agricultural prices in mid-1975 is a result of monetary phenomena which induced an export boom in an economy that was already responding to expansive monetary policies, and in the case of agriculture, increased the foreign demand for U.S. output . . ." (p. 12).

Explanatory Variables

Accurate estimation of the degree of overvaluation of a currency is difficult. When rates were fixed in the 1960s, Floyd (1965b) estimated the overvaluation of the dollar at 10%.[3] When the dollar was allowed to float in 1971, the dollar depreciated by approximately 10%, verifying to a large extent the Floyd estimate.[4] In early 1973 the dollar was devalued again by an average of 10%, but there was a partial reversal by the end of the year. This analysis employs a 10% devaluation of the dollar against all other countries.[5]

The EEC applies a variable levy to wheat imports and automatically insulates the domestic price from changes in foreign prices. In 1972–73 world prices, although high by historical standards, were low relative to the EC threshold price, and the levy averaged $50 per ton. In 1973–74 world prices continued to rise, and the levy fell to zero for most of the year. This encouragement to EC wheat imports was supplemented by an EC ban on exports to certain regions of the world and taxing exports to other regions. By the middle of 1977, the levy was approximately 100% of the import price.[6]

Japan engages in state trading, and its Food Agency is the monopoly importer for wheat. Prior to 1973, the Agency bought wheat at the world price and sold to Japanese millers at a higher price, the difference constituting an effective tariff. In 1973–74 the Agency insulated Japanese consumers from the increase in world prices by selling domestically at a loss. They continued this import subsidy until it was phased out in early 1976.

After the United States, Canada and Australia are the most important wheat exporters. They both employ state trading agencies in the foreign sales of their wheat. In 1973–74 both agencies levied effective export taxes by selling to domestic millers at far below the export price. The Canadian Wheat Board's average export price was $6.00 (Canadian) per bushel, while the price to domestic millers was $3.25. The Australian Wheat Board's export price was 53% higher than its domestic price.

The U.S. government has pursued several policies that have raised shipping costs paid by exporters of U.S. wheat (see Bennathan and Walters, Jantscher).[7] These include the promotion of shipping cartels or conferences that collude to set monopoly freight rates and cargo preference laws that require exporters to use higher cost U.S. ships when cheaper transport is available. An increase in shipping cost lowers the price received by U.S. sellers relative to the price paid by foreign importers. In this respect, it acts as an export tax or a currency revaluation. The ongoing high cost shipping policy depressed the U.S. wheat price in the same way as the overvalued dollar did prior to the 1971 devaluation.[8] Shipping policy did not change in 1973–74, but retaining the historical policy depressed wheat prices relative to what they otherwise would have been. This shipping policy effect can be measured to determine whether it depressed wheat prices more than devaluation raised them.

In order to calculate the net impact of increased shipping costs, one needs to know what fraction of those costs are attributable to government policy. Reliable estimates of this effect are not readily available, but one study has attempted to measure the effect (Bennathan and Walters). They observe that freight rates for U.S. exports exceeded those for U.S. imports by 32%, and they attribute this differential to the cartel.[9]

World Trade Model

In some recent work (Johnson et al.) for a somewhat different purpose, a trade model for grains was formulated that allows isolation of

[3] Houthakker invokes the purchasing power parity theory to obtain an alternative estimate of the degree of overvaluation of the dollar.

[4] This depreciation is taken from the *Economic Report of the President* (Council of Economic Advisers, p. 222). It is measured by the Morgan Guaranty trade weighted index.

[5] The actual average annual rates were zero for Canada and Argentina, 5% for Japan, and 13% for Australia (International Monetary Fund). An approximation was used to avoid specifying an index for the EEC exchange rates. The effect of devaluation with respect to the EEC is reduced by an increase in the variable levy.

[6] The weekly *News* of the USDA reported on 11 May 1977 a levy of $128 per ton when the import price for U.S. no. 2 hard winter wheat was $118.

[7] U.S. shipping policy is also held responsible for raising ocean freight rates by President Ford's Task Group on Antitrust Immunities in its January 1977 report (*The News and Observer*).

[8] American colonial farmers protested that English cargo preference laws depressed the prices of their products. The Navigation Acts required the use of British ships for all trade between England and the colonies, and some colonists complained that this increased transport costs and depressed the price of tobacco that they received (see Rothbard).

[9] The shipping portion of the current five-year U.S.-USSR grain agreement also has the effect of depressing the U.S. price. The agreement specifies a range of exports and a negotiable price with the condition that a certain fraction be carried in high-cost U.S. ships. The shipping condition lowers the Soviet demand at a given price, which reduces export volume and price.

the separate effects of the above variables on the U.S. price of wheat. The model distinguishes wheat by its place of origin.[10]

The view of the world that distinguishes goods by place of origin can be contrasted with the view that underlies spatial equilibrium models of trade such as those of Schmitz and Bawden and Rojko, Urban, and Naive. The latter models are concerned with allocating homogeneous wheat among producing and consuming regions. The main difference between spatial models of homogeneous goods and differentiated goods models is that the latter results in more diversified trade flows. This is to be expected on a priori grounds, since spatial models generate a trade pattern that minimizes transport costs. This difference is confirmed in some comparative experiments (Grennes, Johnson, and Thursby). This model, for instance, allows a consuming region to distinguish among U.S., Canadian, and Australian wheat and to simultaneously purchase all, and at different prices. This view is not new, and it underlies other empirical work in international trade that uses market shares or elasticities of substitution (Harberger, Sirhan and Johnson).

Several straightforward observations of real world behavior support the differentiated good view. Japan does, in fact, buy from many sources; Europe simultaneously imports and exports wheat. Wheat differs by quality, for instance, and there may be blending problems that lead buyers to distinguish different wheats. Importers may vary sources because of security or other political considerations. Tastes may differ among countries. Finally, contractual obligations may present fairly long adjustment lags. For many purposes, even in the case of a single good, the view that wheat can be distinguished by place of origin appears to be a useful abstraction.

The current model was developed as a short-run forecasting model that makes the supply side exogenous. This formulation results in three sets of equations: (*a*) a set of demand equations:

$$(1) \quad Q_{ij} = f(P_{ij}^D, Z_i) \text{ for } i, j = 1, \ldots, n,$$

where Q_{ij} is quantity consumed in country i of wheat originating in country j, P_{ij}^D is consumer price in country i of wheat from country j, and Z_i is exogenous demand shifter for country i; (*b*) a set of price relations:

$$(2) \quad P_{ij}^D = rP_j^S + t_{ij},$$

where P_j^S is the supply price of country j and the t_{ij}'s are exogenous shifters that affect the difference between the origin price and the ultimate consumer prices, and r is the exchange rate between i and j; (*c*) a set of market clearing equations:

$$(3) \quad w_{1j}Q_{1j} + w_{2j}Q_{2j} + \ldots + w_{nj}Q_{nj} = S_j \text{ for } j = 1, \ldots, n,$$

where $\sum_i w_{ij} = 1$, w_{ij} is the fraction of the exports of country j that go to country i (including own consumption $w_{ii}Q_{ii}$), and S_j is the (exogenous) supply in j.

If all countries produced, exported, and imported the good in question, there would be n^2 flows, n^2 demand prices, and n supply prices that can be determined from the n^2 equations in equation (1), n^2 equations in equation (2), and the n equations in equation (3). The known exogenous shifters are the Z_i's, the t_{ij}'s, and the S_j's.[11]

The model consists of six endogenous countries and an exogenous rest of the world (ROW). The countries are the United States (U), Canada (C), Australia (A), Argentina (G), European Economic Community (E), and Japan (J). The endogenous variables of the model are thirteen trade flows, thirteen demand prices, and six supply prices (table 1).

The system used is deterministic. The price elasticities in the demand equations were obtained from Armington-type restrictions (see appendix). The basic elasticities used were an elasticity of substitution (common for all pairs of wheat) of -3.0 and domestic demand elasticities for wheat of -0.2 in the United States and Canada, -0.3 in Argentina and Europe, -0.33 in Japan, and -0.1 in Australia. From these basic elasticities, all the direct and cross price elasticities can be derived.

The model shows the effect on all thirty-two endogenous variables of any exogenous disturbance. The major exogenous variables are demand shifters (income, price of substitute grain, imports by ROW), supply shifters (production and inventory changes), and trade

[10] This model draws heavily on the work of Armington and similar models. One of the main differences is its use here for a single good rather than the more aggregate Standard International Trade Classification classes that have been the usual empirical application of these models.

[11] The model used was actually formulated in changes in the variables. Since the levels can always be recaptured, the simpler statements of equations (1) to (3) are used here.

Table 1. Endogenous Variables in Wheat Model

Trade Flows	Demand Prices	Supply Prices
DUU	DPUU	DSU
DCC	DPCC	DSC
DAA	DPAA	DSA
EGG	DPGG	DSG
DEU	DPEU	
DEC	DPEC	
DEA	DPEA	
DEG	DPEG	
DEE	DPEE	DSE
DJU	DPJU	
DJC	DPJC	
DJA	DPJA	
DJJ	DPJJ	DSJ

Note: DIJ is the change in exports to I from J; DPIJ is the change in the price in I of J's wheat; DSI is the change in the supply price received by I's producers.

shifters (transport costs, trade controls, exchange rates).

The most important shifters for these purposes are the trade shifters that appear in the price equations. These include all the important policy changes, as well as changes in transport costs. Changes in tariffs, export taxes, and exchange rates can be introduced directly through the price equations to determine their effects on the thirty-two endogenous variables. This article is concerned with the domestic price of wheat in the United States (DPUU) and how it is affected by (*a*) dollar devaluation with respect to Europe and Japan, (*b*) lowering of the EEC variable levy, (*c*) higher export taxes by Canada and Australia, and (*d*) U.S. transport policy, which raises shipping costs between the United States and Japan and Europe. Hypothetical effects of each of these four sets of shifters on the price in the United States are shown in table 2.

One can think of the deterministic equations as

$$XY = A, \tag{4}$$

where X is a matrix of demand parameters, export weights, and any other weights that appear as coefficients on endogenous variables, A is a vector of exogenous shifters, and Y is the solution vector of endogenous variables. The inverse of X that is necessary for the solution can be thought of as a matrix of impact multipliers, where each element in the inverse is a partial derivative of an element in Y with respect to an element in A. Once X^{-1} is known, the direct, *ceteris paribus* impact on any endogenous variable from a policy change appearing in A can be found from the appropriate element in X^{-1}.

Wheat Market, 1973–74

Large price increases make 1973–74 a year of great interest, and many policy changes took place whose impacts may be distinguished with the model described above. The separate effects of the explanatory variables on the domestic price of U.S. wheat are estimated. For the devaluation calculation, the impact multiplier on the internal U.S. price of wheat of a change in the difference between the U.S. supply price and foreign demand prices is needed. From equation (2), this multiplier for a devaluation of the U.S. dollar against Japan is $\partial P_{uu}{}^{D}/\partial t_{Ju}$. This multiplier is the same for any change in t_{Ju} such as a transport cost change, tariff change, etc.

The multiplier is evaluated as follows. The

Table 2. Implications of the Wheat Model

Effect on the Price of U.S. Wheat of Exogenous Changes	DPUU (%)
1. Decrease of EEC tariff by 10% on wheat from	
U.S.	2.5
Canada	0.1
Argentina	−0.2
All imports	2.4
2a. Increase in Canadian export tax by 10% on wheat sent to	
Japan	0.3
Europe	−0.1
All markets	0.2
2b. Increase in Australian export tax by 10% on wheat sent to	
Japan	0.2
2c. Decrease in Japanese tariff by 10% on wheat from	
U.S.	0.7
Canada	−0.2
Australia	−0.1
All imports	0.4
Total: 2a + 2b + 2c	0.8
3. U.S. devalue by 10% against	
Europe	5.1
Japan	1.8
All currencies	6.9
4. Increase of 10% in cost of shipping U.S. wheat to	
Europe	−1.0
Japan	−0.4
All markets	−1.4

exogenous shift vector A has all zero entries except the 10% change in the row represented by the equation for the demand price in Japan for U.S. wheat. This vector is then multiplied by X^{-1} to yield the changes in the endogenous variables (Y) that would result from a *ceteris paribus* dollar devaluation in Japan. The specific change examined in this case is the change in the U.S. internal demand price, so the row in X^{-1} corresponding to that equation is multiplied by A and in this case yields a forecast change in the U.S. internal price of 1.8%. Since a devaluation against all other currencies is postulated as well, the calculation must be repeated for the element in Y that corresponds to the European demand price. That forecast is 5.1%, so the total impact on the U.S. internal price from a 10% devaluation against the yen and some average European currency is approximately 7%.[12]

The effects of the insulating trade policies are calculated in a slightly different fashion, and the results are shown in table 3. Column 1 shows the actual price changes in the various markets.[13] Column 2 shows the prices that would have occurred using actual values of 1973–74 exogenous variables, using the 1972–73 trade policies of the EEC, Canada, Australia, and Japan. If those countries had pursued constant trade policies, the U.S. price would have risen by 19.9% in 1973–74. Column 3 repeats the experiment but introduces the EEC's actual 1973–74 trade policy, which was a substantial tariff decrease. By increasing the demand for imported wheat, this insulating policy raises the wheat price in all other countries, increasing it by nearly ten percentage points in the United States. Column 4 repeats the experiment of column 3 but adds the actual insulating trade policies pursued in 1973–74 by Canada, Australia, and Japan. These policies depressed prices in those countries; by adding to the demand for U.S. wheat, they increased the U.S. price by approximately ten more percentage points to 40.8%. Thus, in 1973–74 the tariff policy of the EEC and the combined trade policies of Canada-Australia-Japan each caused a larger increase in the U.S. wheat price than a uniform 10% devaluation of the dollar against all countries.[14]

Table 3. Changes in Real Wheat Prices 1972–73 to 1973–74 for Different Wheat Policies

Country	Actual Change[a]	Estimates: 1972–73 Policies	Estimates: 1972–73 plus EC Variable Levy Change	Estimates: 1973–74 Policies
		%		
U.S.	59.1	19.9	29.3	40.8
Canada	15.7	27.1	39.7	8.5
Australia	−9.0	3.3	14.7	−28.8
Argentina	[b]	126.0	134.6	136.2
Europe	0	34.9	29.9	33.7
Japan	5.4	43.3	52.5	18.7

[a] The actual prices are internal wholesale price changes. The forecast prices are internal consumption price changes for the country's own wheat.

[b] Argentina embargoed wheat exports in early 1973–74 and controlled prices so rigidly that quoted prices are virtually meaningless.

The last explanatory variable investigated is shipping costs. Shipping costs are similar to devaluation in that they drive a wedge between a domestic supply price and a foreign demand price. Taking the 30% artificial increase in costs introduced above, a shift to a freer market in shipping in 1973–74 would have lowered the U.S. wheat price by 7%. We do not have great confidence in the exact numbers, but the example is instructive.

Dollar devaluation contributed to the rise in the U.S. domestic wheat price in 1973–74.

[12] If other importers were endogenous, this percentage would be different. However, 7% is not necessarily a lower bound for the exchange rate effect. After Japan and the EEC, the major importers of U.S. wheat are Communist countries or developing countries. The next five importers (in order) in 1973–74 were USSR, Korea, India, Brazil, and Algeria. In most Communist countries, currencies are inconvertible, and prices are less important in determining the volume of imports. In nearly all developing countries, the dollar appreciated in 1973–74, which should have decreased the U.S. price.

The Schuh reference that represents the focal point of the devaluation argument is concerned with all agricultural exports, while the text is only concerned with wheat. The argument for the smallness of the devaluation effect thus may not generalize. For wheat, 25% of U.S. exports went to Europe and Japan, for corn, 54% went to the EC and Japan, while for soybeans 65% went to the EC and Japan. (Of soybean oil, hardly any went to the EC and Japan.) The effect on all agriculture might be understated by using the wheat figure, but it must also be remembered that for all U.S. imports the effects run the other way.

The effect in the text is net of any EC variable levy offset. When the "world" price is below the EC internal price (the normal situation), the variable levy provides an automatic (essentially) offset, attenuating any overvaluation effect. See next paragraph in text.

[13] The percentage changes in the actual change columns are computed as arc-type changes; that is, for a variable X in periods 1 and 2, our percentage change is $(X_2 - X_1)/[1/2(X_2 + X_1)]$. The nominal, yearly average Kansas City price per metric ton of wheat changed from $83.04 to $169.39 between the two years. The base of a percentage change is ultimately arbitrary; very large changes can lead to quite different comparisons between different bases.

[14] Josling uses a different technique to measure the effect of changes in government trade policy on agricultural trade in the 1970s. He converts all trade controls into equivalent producer and consumer subsidies, and his results in terms of the importance of insulating trade controls are similar to ours.

This monetary effect should not be ignored, but neither should it be exaggerated. In the same year the insulating policies that restrained wheat exports and encouraged wheat imports had a more powerful effect in raising the U.S. wheat price. For a general discussion of the trade-offs between exchange rate and tariff policies for agricultural exports, see Scobie and Johnson. The U.S. shipping policy that raised transport costs depressed the wheat price at least as much as devaluation raised it.

Overvaluation and Factor Prices in Agriculture

The impact of the policies discussed above is not confined to the price of the product involved. Product prices affect factor prices if factors are specific to the industry. Agricultural land is an obvious example of such a factor, and specialized labor may be a quasi-fixed factor. Lopes and Schuh, in a sequel to the Schuh reference, look at this distributional aspect of international trade distortions and product price changes. They point out that a persistent overvaluation of the dollar, absent any other changes, has the effect of lowering product prices and thus land rents. This has the opposite effect on factor rewards to land from the usual array of income support measures for agriculture.

Floyd (1965a) constructed a six-equation model of the agricultural sector that provides links between product and factor prices. He provides numerical estimates of the parameters of the system, so that for specified policies affecting agricultural output limits can be put on the resulting changes in output price, factor use, and factor prices. Lopes and Schuh use this framework for their qualitative analysis. It should be instructive to carry the analysis further by using the numbers adduced in the first part of the paper to calculate some impacts on factor rewards. Specifically, the relative size of the impact of overvaluation and trade controls on factor prices is measured.

How important were monetary forces in altering agricultural land values in 1973–74? This is a complex question, since land has many alternative uses and this model concentrates on wheat. However, some insights might be gained into the relationship by noting that most product prices (food grains, feed grains, soybeans, and cotton) tended to move together during this period, so that the wheat price might serve as a crude index of all other prices.

Floyd's (1965a) model implies that factor prices rise relative to product prices, the specific limits for the factor price change being 1.5 to 3 times the product price change. This model predicts that a 10% devaluation increases wheat prices by 7%. Thus, the implied increase in land rent resulting from a 10% devaluation is 10.5% to 21%. Is there any evidence that land markets reflected changes of this magnitude?

Table 4 contains land price data for 1970–75 for the real land price (reported values deflated by the CPI), the index of prices received for agricultural products, the ratio of prices received to the index of prices paid, and the consumer price index (CPI). Comparing the land price change in each year with the preceding year's product price change, it can be seen that in no year was the land price change as large as the product price change. A devaluation occurred in 1971, and product prices rose 7% in real terms, while land values increased 4.5%. In 1973–74, there was a devaluation just prior to the beginning of the U.S. crop year. The real price of farm products rose by 19%

Table 4. Real Land Price per Acre of U.S. Farmland and Price Indexes, 1970–75

Year	Real Land Price ($/Acre)	Percentage Change	Index of Prices Received	Price Ratio (1967 = 100)[a]	CPI
1970	167.7		110	96	116.3
1971	167.3	−0.3	112	93	121.3
1972	174.8	4.5	126	100	125.3
1973	185.6	6.2	172	119	133.1
1974	209.9	13.1	184	109	147.7
1975	219.6	4.6	186	103	161.2

Sources: USDA 1975, 1976a, b.
[a] Index of prices received divided by index of prices paid.

from the calculations in table 4, while the land price rose by 13.1%. For this year, land prices rose less than the all-product index, less than observed wheat prices, and less than our forecast wheat prices. These crude data do not seem consistent with the view that devaluation had a major effect on land markets.

The above evidence may not be a refutation of Floyd's (1965a) model, since a number of identification problems associated with the table were not considered. Since land is a durable asset, it should be important to distinguish between transitory and permanent changes in land rent. The price of land is the present value of future expected land rent, and an event that raises present rent but not future rent causes only a small increase in the land price. A possible explanation is that the variables that raised grain prices were perceived as transitory; these perceptions have been vindicated by subsequent experience. All of the policies held responsible for raising prices in 1973–74 have subsequently been reversed. Japan has returned to its previous tariff policy, and the ECC has a higher wheat tariff in 1977 than it had in 1972. Canada, Australia, and Argentina are now promoting wheat exports instead of restricting them as they did in 1973–74. Although the dollar has moved unevenly against other currencies, on the average the 1973–74 devaluation has been more than reversed, since the dollar is worth 5% more in May 1977 than it was in February 1973 in terms of the Morgan Guaranty index. These transitory changes should not be expected to have a large impact on land prices.

The relationship between devaluation and land prices deserves more systematic study than is provided here. However, this interpretation of the data is that land prices rose less than product prices, and much of the observed product price increase seems attributable to government policies other than devaluation. Since this does not leave much of a residual to be explained by dollar devaluation, the tentative conclusion is that devaluation was probably not the dominant factor in the agricultural land market in 1973–74.

Conclusions

Many distortions can be found in the international pricing of grains, including the international market for wheat in 1973–74. In addition to a dollar devaluation that took place at that time, all the major importers and exporters except the United States adopted insulating policies to protect their consumers from sharply rising prices. The dollar devaluation was of lesser importance for the U.S. domestic price than foreign commercial policy. Fragmentary evidence indicates that continuation of distortions in U.S. shipping policy was as important as the devaluation of the dollar.

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Appendix

The Workings and Sensitivity of the Model

Care is necessary in isolating causes for certain relative price changes for agricultural products. The evidence in this article comes from a structure involving thirty-two endogenous variables, but the current effort does not warrant the space necessary to set out the model in its complete statement. The reader may legitimately ask about the validity of the numbers used. The purpose of this appendix is to make some succinct statements about the model and say something about the sensitivity of the numbers to different assumptions and events.

As noted in the text, the basic structure consists of equations (1) to (3), which relate thirteen flows, thirteen demand prices, and six supply prices to certain exogenous shifters. The coefficients on these endogenous variables (the X matrix in equation (4)), are the direct and cross price elasticities of demand, a set of weights on P_j^S in equation (2) (taken to be 1's here), and the export share weights w_{ij} in equation (3). The direct and cross price elasticities are found from a set of restrictions on the parameter space that allows their calculation from some basic demand elasticities and (in our case) a basic elasticity of substitution among different kinds of wheat. These restrictions are basically those of Armington. His model, and our variant, can be derived by formally maximizing an underlying utility function in a two-stage process. For these purposes, the significant feature of the model is the result and not the exact nature of the restrictions. A significant reduction in information necessary for parameter estimation is achieved. Using a common elasticity of substitution, only $n + 1$ basic elasticities are needed to generate the n^2 implied demand elasticities. (For details, see Armington or Johnson et al.) The calculations involve the use of import shares of particular kinds of wheat into each market. These shares are one in the case of the major exporters, which only import from themselves, and they

Table A.1. Selected Multipliers from Reduced Form

Exogenous Shifter	Multipliers for U.S. Internal Price
Demand shift	
UU	1.51
EU	0.19
JU	0.23
CC	0.13
EC	0.08
JC	0.05
AA	0.61
EA	0
JA	0.08
GG	0.08
EG	0.01
EE	0.85
JJ	0.05
Demand price change	
UU	0.69
EU	−0.51
JU	−0.18
CC	−0.03
EC	−0.05
JC	0.07
AA	−0.06
EA	0.10
JA	−0.04
GG	−0.02
EG	0.02
EE	0
JJ	0
Change in supply	
U	−3.78
C	−0.46
A	−2.04
G	−0.10
E	−0.95
J	−0.05
Exogenous exports to ROW	
U	1.85
C	0.20
A	1.35
G	0.02
E	0.10

vary for the importers such as Japan and Europe. The weights (w_{ij}) are found from the observed export shares of country j's exports to country i in some particular time period.

The forecasts from the model vary according to the accuracy of the basic elasticities and according to the behavior of past exports and imports. Import shares for the regions considered in this article have been quite stable compared with export shares. A ten-year average for these shares is used calculating elasticities. The basic elasticities used are close to those used by other researchers and do not appear to be a cause of concern. The elasticity of substitution (σ) used (3) is on less firm ground. However, two considerations ameliorate our concern. An estimate of 3 from direct estimation of this elasticity in both the Japanese and British markets cannot be rejected statistically. Second, some sensitivity analyses of varying values of σ indicate the model is not particularly sensitive to different values. It is difficult to make this last point with precision, but a change in an exogenous shifter such as transport costs of 10% has much more impact on forecast values than changing σ by a factor of two.

Our use of the model has utilized the previous year's weights (w_{ij}) for each forecast. This article concentrates on a particular year, 1973–74, so the export shares for 1972–73 enter the matrix X of coefficients on the endogenous variables. At the moment this procedure is dictated by the logic of the model, but in practice it is not sacrosanct.

The information in X is treated as deterministic, so that a reduced form set of equations for equation (4) can be found as

$$Y = X^{-1}A. \tag{A.1}$$

A particular solution for given exogenous shifters in A is then found by evaluating equation (A.1) for Y.

Table A.1 amplifies the discussion in the text of the 10% devaluation of the dollar. The left-hand column headed exogenous shifter shows thirteen flows, thirteen demand price changes, and six supply price changes as well as five exogenous export shifters. These identify the row in A (the equation in the structure) where an exogenous shock is going to take place. The right-hand column lists the elements of row 14 in the inverse of X. Row 14 is the equation for the change in the demand price for U.S. wheat.

The forecast price change in 1973–74 for the internal price of U.S. wheat is the sum of these multipliers each multiplied by the corresponding exogenous shock. Looking down that column, one can see the large changes are from a change in demand such as income or competing prices, a change in supply, or a change in ROW exports. For instance, a 10% change in projected shipments to the USSR increases the U.S. price by 18.5%, *ceteris paribus*.

The devaluation example involves the multipliers for the price differences EU and JU. A 10% devaluation is equivalent to a shift in those two equations of 10%; the multipliers are -0.51 and -0.18 for Europe and Japan, respectively. The sum of the effects on the U.S. price are 5.1% and 1.8% for a total increase of 6.9%.

The Impact of Trade Restrictions on Price Stability in the World Wheat Market

Shun-Yi Shei and Robert L. Thompson

A thirteen-region quadratic programming model of world wheat trade is utilized to simulate the effects of unanticipated quantity changes on prices in the world wheat market under different degrees of trade restriction. Three scenarios characterized by different numbers of regions that permit price signals from international markets to be reflected into their domestic markets are specified. As the number of countries whose wheat trade is price responsive increases in the simulations, the percentage change in world price is smaller in response to a shock such as U.S. export controls or an unanticipated change in Soviet imports.

Key words: export control, export demand, simulation, stability, trade model, wheat.

Price stability has emerged as an important issue in agricultural policy discussions in the past several years. The increased price instability in U.S. grains markets in the 1970s compared with an earlier period has been associated with greater dependence on the world market, a reduced level of stocks, and the near elimination of our land reserve. In this period a number of shocks to international grain markets have occurred, including two Soviet crop failures and varying degrees of U.S. export controls. A number of theoretical analyses of the social gains and losses from price stabilization are available (for a summary, see Just). There have also been a number of simulation studies of the effects of various stocks schemes to stabilize domestic and/or world wheat prices (e.g., Sharples, Walker, and Slaughter; Cochrane and Danin; Reutlinger).

D. G. Johnson, Schuh, and the U.S. Council of Economic Advisers have argued that trade restrictions or barriers to free agricultural trade are important causal factors in increasing instability in world markets. The theoretical arguments concerning the global gains from free trade due to more efficient resource use are well known. Less well recognized are the price-stabilizing effects of free agricultural trade. Nontariff trade restrictions, such as quantitative controls and variable levies, cut the link between the world market price and the domestic price. These force all of the adjustment in response to crop failures and other shocks to the system onto those countries that do permit world price signals to be reflected in their domestic markets.

Multilateral trade negotiations under the General Agreement on Tariffs and Trade (GATT) are now going on in Geneva, and barriers to agricultural trade are on the agenda. However, many industrial countries maintain their domestic agricultural prices above the world market level through some combination of price supports, variable levies, and quantitative restrictions on trade with the objective of raising farm income. As long as present domestic policies continue, negotiation of freer agricultural trade will be precluded, and few countries consider their domestic policies negotiable in international fora. Therefore, many observers doubt that any more progress will be made in removing agricultural trade barriers than occurred during the Kennedy round of trade negotiations.

In discussion of world price stability, repeated calls are made for a New International

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Shun-Yi Shei is a graduate student and Robert L. Thompson is an assistant professor in the Department of Agricultural Economics, Purdue University.

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Economic Order. This usually involves greater international commodity trade restriction via buffer stocks, commodity agreements, cartels, and the like. There is also some tendency towards longer term export contracts or purchase agreements. Such moves are in the direction of greater trade restriction, not less.

The premise of this article is that, if price stability in the world market is desired, trade liberalization, not greater restriction, is more likely to provide it. A simple model of world wheat trade is utilized to simulate the effects of abrupt quantity changes on prices in the world wheat market under alternative assumptions concerning the number of regions of the world that permit price signals from international markets to be reflected into their domestic markets. The model is specified for 1972–73, a crop year in which world supply was very tight and prices of wheat rose substantially above historical levels. The model is used to simulate the effects of two hypothetical shocks to the world market: a purchase by the Soviet Union of about half as much wheat as was actually purchased in 1972–73, and imposition by the United States of a global export quota on wheat exports in order to restrain the rapid rise in the domestic price. The article deals with the central issue of trade liberalization and price stability and incidentally provides rough estimates of the potential impact of such shocks on the world trade flows in wheat.

Theoretical Framework

This section illustrates the effect of a shock to the international market on price in exporting and importing countries under varying degrees of price responsiveness of the participants in the world market. A one-commodity, two-country trading world is assumed initially in order to simplify the presentation of the theoretical framework. It is assumed that the single homogeneous commodity is produced and consumed under competitive conditions in both trading countries. Transportation costs are ignored at this point and, for simplicity, fixed exchange rates are assumed. In the empirical thirteen-region model below, transportation costs are explicitly introduced.

Figure 1 presents the theoretical framework in graphical terms. In the outside panels the domestic supply (S_i) and demand (D_i) curves of the exporting (1) and importing (2) countries are represented. The center panel, which represents the world market, contains the excess supply curve (ES_1) of country 1 and the excess demand curve (ED_2) of country 2. Under free trade, the market price is equalized in both trading countries at $OA = OH = OM$, and country 1 exports $EF = OK = VY$ to country 2.

Assuming a drought in the importing country shifts its supply curve from S_2 to S'_2 and its excess demand curve from ED_2 to ED'_2, the equilibrium price in both countries rises to $OB = OI = ON$, and exports from country 1 to country 2 increase to $CG = OL = TX$. Under free trade, shocks to the system such as a short crop in the importing country are transmitted through the world market into the exporting country such that both countries share in the adjustment. The greater the slope of the domestic supply and/or demand relation in

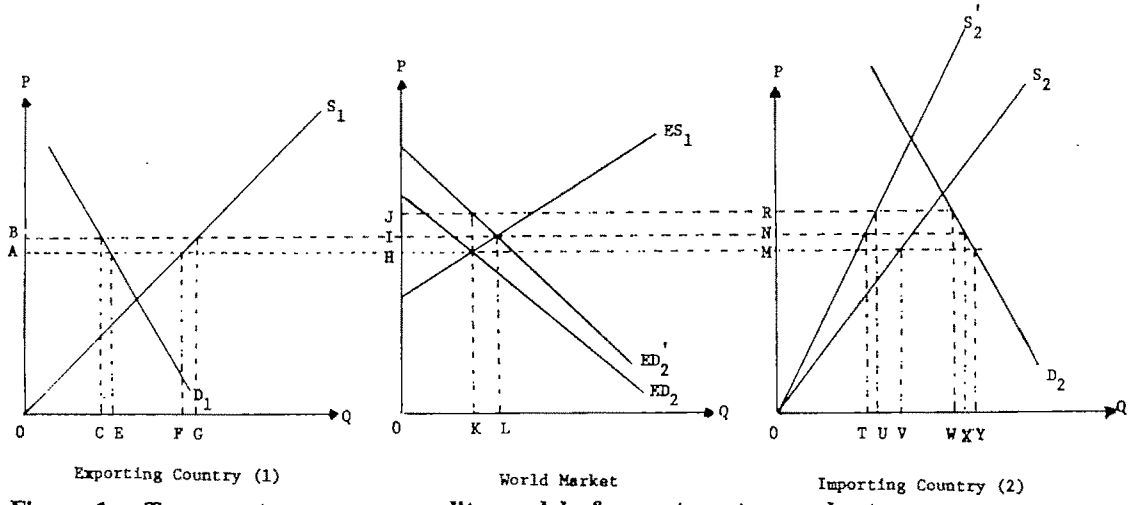


Figure 1. Two-country, one-commodity model of export quota on wheat

each region, the less the price adjustment necessary to clear the market in response to a shock, *ceteris paribus*. This is equivalent to saying that the more elastic the excess supply and excess demand relations, the larger is the quantity adjustment in the volume of trade and the smaller is the price adjustment in response to the shock.[1]

The exporting country can avoid sharing in the adjustment to shocks in the importing country and thereby stabilize its domestic price by cutting the link between the domestic and world market prices. This may be accomplished by means of a quantitative export restriction or an export tax. In figure 1, country 1 can stabilize the domestic price at OA by limiting exports to $EF = OK$ or by imposing an export tax of HJ per unit.[2] At level OK of exports the world market price is bid up to OJ, which equals OR in the importing country. This exceeds the equilibrium price under free trade, $OI = ON$. Since the exporting country refuses to share in the adjustment to the crop shortfall in the importing country, the price adjustment required to clear the world market is greater.

The importing country could have attempted to stabilize its domestic price at OM by increasing its import of the product to ZY. This would have increased the price in the exporting country to a level above OB. Here, the failure of the importing country to let its price adjust forces a larger adjustment onto the exporting country than it would otherwise have experienced.

The theoretical framework has been presented in terms of a two-country world for facility of presentation. The importing country might be considered the rest of the world, whose "domestic" supply and demand curves would be, respectively, the horizontal sums of the domestic supply and demand relations in all other countries, importers and exporters alike. The excess demand relation confronted by the exporting country would then be a net excess demand relation (total imports of all importers minus the exports of all other exporting countries). When there are multiple exporting countries in the market, the price elasticity of excess demand confronted by each independently would be greater than if it were the only exporter in the market. When an importing country cuts the price link between its market and the world market by quantitative restrictions or variable levies, its elasticity of excess demand is perceived to be zero by the other world market participants. This reduces the elasticity of excess demand confronted by any individual exporting country. As above, since fewer countries share in the adjustment in response to any shock to the system, the price adjustment required to clear the market is greater.

The Empirical Model

At first sight the simplest means of utilizing the framework described in the previous section to estimate the effects of shocks to the world wheat market appears to be to directly estimate the domestic U.S. supply and demand functions and an aggregate excess demand function for the rest of the world.[3] This procedure was not employed in this study, however, because the direct estimation of an aggregate excess supply or demand relationship for the rest of the world is notoriously laden with econometric problems (see Magee and Leamer and Stern for discussions of the econometric problems associated with directly estimating such excess demand relationships). In addition, it does not permit explicit account to be taken of the effects of market distortions and transportation costs on the volume of trade flows. Instead of attempting to utilize a

[1] The price elasticities of excess supply and excess demand are, respectively,

$$\epsilon_i = \frac{dQ_i^X}{dP_i}\,\frac{P_i}{Q_i^X} = g_i\left(\frac{Q_i^S}{Q_i^X}\right) - e_i\left(\frac{Q_i^D}{Q_i^X}\right)$$

and

$$\eta_i = \frac{dQ_i^M}{dP_i}\,\frac{P_i}{Q_i^M} = e_i\left(\frac{Q_i^D}{Q_i^M}\right) - g_i\left(\frac{Q_i^S}{Q_i^M}\right);$$

where for country i, Q_i^S is the domestic production, Q_i^D is the domestic consumption, Q_i^X is the export quantity, Q_i^M is the import quantity, e_i is the domestic price elasticity of demand, and g_i is the domestic price elasticity of supply. These formulas, which have become common in the literature, are attributed by Orcutt to Yntema (pp. 43–45).

[2] While *ad valorem* and specific tariffs drive a wedge between domestic and world market price, the price signals still get through from the world market to the domestic market, albeit in a distorted form. In effect, a tariff rotates the excess demand curve of the rest of the world, making it less elastic; a quota or a variable levy turns it vertical over a range of prices.

[3] The price elasticity of an excess demand function for U.S. wheat exports has been directly estimated by P. R. Johnson at −3.8 using data from 1951–63. His estimate is much more elastic than that of Meinken based mainly on prewar data. Fletcher and Just estimate short-run price elasticities of import demand for U.S. wheat exports in four regions of the world. Their estimated elasticities are: (*a*) Western Europe, −0.10, (*b*) Asia (including PRC), −1.32, (*c*) Western Hemisphere (excluding United States and Canada), −0.52, and (*d*) all other importers (Africa, USSR, Eastern Europe, and Oceania excluding Australia), −1.49 (pp. 8–9).

direct estimate of an excess demand function of the rest of the world for U.S. wheat exports, a small quadratic programming model of world wheat trade of the type developed by Takayama and Judge was specified. (A full presentation of the model specification, data utilized including transportation costs, and limitations of the model is contained in Shei.) This implicitly provides the excess demand function of the rest of the world that the United States confronts.

The world wheat market is divided into five exporting regions (the United States, Canada, Australia, Argentina, and the European Economic Community (EEC)) and nine importing regions (Japan, People's Republic of China (PRC), USSR, EEC, Other Western Europe, Eastern Europe, Other South America, Other Asia, and Africa). Wheat is taken here to be a homogeneous commodity. Three alternative specifications of the world wheat trade model are formulated to permit simulation of the effects of shocks to the world wheat market under varying assumptions concerning the number of importing countries that permit world market price signals to be reflected in their domestic markets. The basic specification of the model assumes that the imports of all importing regions and the exports of the EC are fixed (assumed not price responsive) at the 1972–73 observed levels.[4] Only exports from the United States, Canada, Argentina, and Australia are assumed to be price responsive. We shall call this specification scenario 1.

This specification is considered an extreme case in its rather unrealistic assumption that the excess demand or import quantities of all countries are fixed and do not respond to price changes—even, say, in the face of a doubling of the world market price. (Countries with zero price elasticity of import demand over some range of prices may have nonzero elasticities at higher prices.) Scenario 2 is identical with scenario 1, except that the imports of Other Asia, Africa, and Other South America are also made price responsive. This specification is consistent with D. G. Johnson's description of the world grains economy. Scenario 3 is the full free trade case in which all importing and exporting regions are assumed to be price responsive.

The linear excess supply functions utilized in the annual quadratic programming model are based on Liu's recent econometric estimates of domestic supply and demand relations in the principal wheat exporting countries. To generate short-run excess supply relations, it is assumed that, once the crop is planted, that year's production is no longer price responsive within the crop year. Therefore, each country's production in 1972 is taken as fixed. Liu's demand equations are "collapsed" (expressed as functions of only current prices) by substituting the respective values of all other explanatory variables for 1972 into the respective equations. Each country's short-run excess supply equation then equals the fixed supply quantity minus its domestic demand equation. Observed changes in stocks in 1972–73 are treated as exogenously given intercept shifters in the respective excess supply equations.[5]

For the United States: $Q^X = 21{,}851 + 64.427P$; $\epsilon = 0.20$; Canada: $Q^X = 15{,}926 + 2.625P$; $\epsilon = 0.02$; Australia: $Q^X = 8{,}029 + 1.972P$; $\epsilon = 0.03$; Argentina: $Q^X = 791 + 12.089P$; $\epsilon = 0.30$; and EEC: $Q^X = 3{,}291 + 122.25P$; $\epsilon = 2.38$; where Q^X is the volume of excess supply of wheat in thousands of metric tons; P is the domestic market price in U.S. dollars per metric ton (converted at official par value rates of exchange following Bjarnason, McGary, and Schmitz);[6] and ϵ is the short-run price elasticity of excess supply at observed 1972–73 prices and quantities for each respective country.

No excess demand equations for importing countries were estimated by Liu. To specify

[4] Certain wheat-importing countries maintain their domestic wheat price above or below the world market level, necessitating some form of trade control to sever the link between the domestic and world market prices. For example, the link between internal EEC agricultural prices and world market prices is cut by means of the variable import levy and export tax. The Japan Food Agency, which is the sole importer of wheat in Japan, has variously resold wheat in the domestic market at prices above and below the import price. In centrally planned economies, the quantities demanded and supplied may not be determined by a market mechanism.

[5] The assumed non-price responsiveness of stock-holding activities is probably a rather restrictive assumption. One anonymous *Journal* reviewer argued that non-price responsiveness legislated by some importing countries might be expected to increase the price responsiveness of the remaining countries through increased storage activity. To the extent that this occurs, greater world price stability than suggested by this study would be expected. A number of simulation studies of reserve stock behavior have been carried out in which the effect of trade restrictions on price stability has tended to be ignored. This study focuses upon the latter issue, ignoring the former.

[6] Fixed or unchanging exchange rates are assumed. Under a floating exchange rate regime, this would require that the value of trade in wheat be insignificant relative to the total value of international transactions on current and capital account in the countries included in the model. Failing this, as the total value of trade in wheat between a pair of countries increases, one would expect the currency of the importing country to depreciate relative to that of the exporting country.

scenarios 2 and 3, excess demand relations for each importing region were synthesized by Shei. Estimates of the domestic price elasticities of demand for wheat in a number of countries have been estimated by Rojko, Urban, and Naive, and data on volumes of domestic consumption and imports (International Wheat Council) were utilized in synthesizing an excess demand equation for each importing region.

To calculate short-run price elasticities of import demand, it is assumed that, once the crop is planted, that year's production is no longer price responsive within the crop year. Therefore, the short-run price elasticity of excess demand in a given region is taken to be $\eta = e(Q^D/Q^M)$, where e is the domestic price elasticity of demand, Q^D is the quantity demanded domestically, and Q^M is the quantity imported in the respective country. The estimate of η calculated in this manner should be a lower bound estimate of the price elasticity of excess demand because no price responsiveness of supply or change in stocks is permitted. The resulting import demand equations, which are admittedly somewhat crude estimates, are as follows: Japan: $Q^M = 7{,}476 - 19.1721P$; $\eta = -0.35$; PRC: $Q^M = 8{,}410 - 30.0049P$; $\eta = -0.59$; Other Asia: $Q^M = 26{,}596 - 134.3731P$; $\eta = -1.13$; USSR: $Q^M = 35{,}528 - 204.6402P$; $\eta = -1.33$; E. Europe: $Q^M = 6{,}538 - 56.0224P$; $\eta = -4.72$; EEC: $Q^M = 20{,}085 - 149.42P$; $\eta = -2.41$; Other W. Europe: $Q^M = 6{,}025 - 48.8055P$; $\eta = -3.93$; Africa: $Q^M = 10{,}940 - 48.083P$; $\eta = -0.78$; and Other S. America: $Q^M = 8{,}733 - 25.1786P$; $\eta = -0.40$; where Q^M is the excess demand for wheat in thousands of metric tons, and η is the price elasticity of excess demand calculated at observed 1972–73 prices and quantities for each respective region. The price elasticity of excess demand η varies considerably among countries. This is not unexpected, since, *ceteris paribus*, the smaller the fraction of a country's consumption that is imported, the larger its elasticity of excess demand.

Empirical Results

The trade flows and prices contained in the solution of the basic model specification (scenario 1) are presented in table 1. The quadratic programming model restricts the number of trade flows in solution to one less than the total number of exporting and importing regions (i.e., 5 + 9 − 1 = 13 in this case).[7] Bearing this in mind, the results generated by the model replicate fairly closely the principal observed trade flows in 1972–73 presented in table 2, with one main exception. Africa was the EEC's most important wheat export market in 1972–73. In the solution, however, Africa is entirely supplied by the United States, and Other Asia takes all of the EEC's exports

[7] The quadratic programming algorithm QP360 developed by Cutler and Pass at the RAND Corporation was employed to solve the model. Because of the transportation constraints and the nature of the solution algorithm utilized, the total number of trading activities must be one less than the total number of origins (m) and destinations (n), i.e., exactly equal to $n + m - 1$.

Table 1. Simulated Exports of Wheat, 1972–73, Scenario 1

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	5,538					5,538	101.1
PRC		4,128	1,161			5,289	104.0
Other Asia			7,050		5,436	12,486	105.0
USSR	10,332	4,916				15,248	99.1
E. Europe	1,143					1,143	96.3
EEC		5,890				5,890	95.0
Other W. Europe		1,222				1,222	98.4
Africa	6,146					6,146	99.7
Other S. America	4,340			1,898		6,238	99.1
Total	27,499	16,156	8,211	1,898	5,436	59,200	
Export price (U.S. $/metric ton)	87.7	87.5	92.4	91.6	90.9		

Table 2. Exports of Wheat by Source and Primary Destination, 1972–73

Destination	Source					Total
	U.S.	Canada	Australia	Argentina	EEC	
	1,000 Metric Tons					
Japan	3,377	1,364	717	80	—	5,538
PRC	591	4,374	324	—	—	5,289
Other Asia	7,257	1,421	1,430	1,000	1,378	12,486
USSR	9,468	4,168	908	—	704	15,248
E. Europe	817	142	135	—	49	1,143
EEC	2,788	2,227	501	374	—	5,890
Other W. Europe	900	108	33	—	281	1,222
Africa	1,724	536	841	33	3,012	6,146
Other S. America	3,072	556	575	2,023	12	6,238
Total	29,894	14,896	5,464	3,510	5,436	59,200
Export price (U.S. $/metric ton)	92.35	90.94	90.90	85.98	105.93	

Source: International Wheat Council, pp. 37–39, 55–56.

of wheat. The discrepancy between the solution and observed EEC exports may be due to former colonial ties, bilateral trade agreements, and/or special credit arrangements that affect the pattern and flow of world wheat trade but that are not adequately represented in the model.[8] A second discrepancy is that the EEC is solely supplied by Canada and Japan by the United States in solution, while in reality both Canada and the United States were important suppliers of both markets. A possible explanation may lie in the assumption that wheat is a perfectly homogeneous commodity. In reality, many varieties and qualities exist. Moreover, an importing country may not consider otherwise identical wheat supplied by two different exporters to be perfect substitutes. A country's desire to diversify its source of import supply would be consistent with such behavior.[9]

The solution export and import prices are fairly close to observed levels in 1972–73. For example, the U.S. export price in solution is $87.7 per metric ton, while the observed average price was $92.4.

The model solution for scenario 2, in which the three developing country importers are assumed to be price responsive, is almost identical to that of scenario 1 presented in table 2.

The results from running scenario 3, the full free trade case, are presented in table 3.

[8] Rich's study of trade patterns between the United States and Western Europe suggests that the difference is due to bilateral agreements between Western Europe and the African countries.

[9] Armington developed the theory for a class of trade models in which import goods are distinguished by their place of origin. P. R. Johnson argues for analysis of substitution and market share relations in agricultural trade research.

Table 3. Simulated Exports of Wheat, 1972–73, under Free Trade, Scenario 3

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	5,721					5,721	91.56
PRC			5,594			5,594	93.86
Other Asia			2,598		11,252	13,850	94.86
USSR	8,385	8,815				17,200	89.56
E. Europe	1,482				195	1,677	86.76
EEC		7,315				7,315	85.46
Other W. Europe					1,717	1,717	88.26
Africa	6,605					6,605	90.16
Other S. America	4,695			1,783		6,478	89.56
Total	26,888	16,130	8,192	1,783	13,164	66,157	
Export price (U.S. $/metric ton)	78.16	77.96	82.26	82.06	80.76		

Under free trade conditions, the total volume of wheat moving in world trade increases rather dramatically and at lower prices. This is accounted for mainly by the large increase in EEC wheat exports under free trade that has been exogenously fixed at a substantially lower level in scenario 1. The scenario 1 solution presented in table 1 is closer to the observed wheat trade flows and prices than the free trade case in table 3. This suggests that the real world may be somewhat closer to the base case than to the full free trade case.

The results presented here for the three scenarios provide a basis for comparison with the simulated effects of shocks to the world wheat market.

Sudden Change in Soviet Purchase

About 80% of the year-to-year fluctuations in world wheat trade since 1960 have been accounted for by swings in USSR imports (Mackie). In 1972–73 the Soviet Union purchased 15.3 million metric tons of wheat on the world market—an increase of about 12 million metric tons from the purchase of the previous year. This level of Soviet imports is reflected in the scenario 1 specification.

The first shock to the world wheat market to be evaluated here is the case of the USSR importing only 7.0 million metric tons of wheat instead of the observed 15.3 million metric tons. When scenario 1 is rerun with this change, all export prices are driven to zero. The positive import prices equal the transportation cost from the supplying country. Table 4 presents the model solution under scenario 2. When only three importing regions are made price responsive, the world wheat price is not nearly as severely depressed by the "shock" as in scenario 1. While USSR imports fell by 8.248 million metric tons, total wheat trade declined by only 2.348 million metric tons. The three price-responsive import regions collectively increased their imports by 5.9 million metric tons.

Table 5 illustrates the effect of the smaller Soviet purchase when all exporters and other importers are assumed to be price responsive (scenario 3). The percentage fall in world market prices is substantially smaller in this case than in the previous case. (The results in tables 4 and 5 should not be compared; rather, they should be compared with those in tables 1 and 3, respectively.) The results are all consistent with the implications of the theoretical framework specified.

U.S. Export Controls

Given the high level by historical standards of Soviet wheat imports in 1972–73, one might ask what the price and trade effects would have been if the United States had imposed global export controls on wheat exports to stop the run-up in price in the United States. In 1972–73 the United States exported 29.9 million metric tons; in the base case solution U.S. exports are 27.5 million metric tons. Although the model is not exactly on target, the latter is taken here as the basis for comparison. The U.S. excess supply equation presented above suggests that by reducing exports from 27.5 to 26 million metric tons the

Table 4. Simulated Exports of Wheat, 1972–73, Scenario 2 with Soviet Imports Limited to 7 Million Metric Tons

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	5,538					5,538	72.10
PRC		5,289				5,289	75.00
Other Asia		2,670	8,156		5,436	16,262	76.90
USSR	5,992	1,008				7,000	70.10
E. Europe	1,143					1,143	67.30
EEC		5,890				5,890	66.00
Other W. Europe		1,222				1,222	69.40
Africa	7,540					7,540	70.70
Other S. America	5,420			1,548		6,968	70.10
Total	25,633	16,079	8,156	1,548	5,436	56,852	
Export price (U.S. $/metric ton)	58.70	58.50	64.30	62.60	62.80		

Table 5. Simulated Exports of Wheat, 1972–73, Scenario 3 with Soviet Imports Limited to 7 Million Metric Tons

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	6,000					6,000	77.00
PRC		4,515	1,498			6,013	79.90
Other Asia			6,666		9,059	15,725	80.90
USSR	4,913	2,087				7,000	75.00
E. Europe	2,493					2,493	72.20
EEC		9,491				9,491	70.90
Other W. Europe					2,399	2,399	74.30
Africa	7,305					7,305	75.60
Other S. America	5,238			1,607		6,845	75.00
Total	25,949	16,093	8,164	1,607	11,458	63,271	
Export price (U.S. $/metric ton)	63.60	63.40	68.30	67.50	66.80		

domestic U.S. wheat price would be expected to fall to $64.4 per metric ton. This is about the price level of the previous year and close to the average annual level of the 1960s.[10]

The three scenarios were rerun under the constraint that U.S. exports of wheat could not exceed 26 million metric tons. In scenario 1 in which no importers are price responsive, when the United States insulates its domestic market from world market price signals by imposing global export controls, the world market price is pushed up markedly. As illustrated in table 6, the U.S. export price in solution more than doubles from $87.7 to $177.5, and the U.S. domestic price falls from $87.7 to $64.4 per metric ton.

In this scenario, all of the decrease in U.S. exports from imposing export controls comes out of its exports to the USSR and Other South America. Argentina makes up for the latter and Canada for the former. As Canada's exports to the USSR rise, its exports to the PRC decrease, which is made up by Australia. The 1,499,000 metric ton reduction in U.S. exports is offset by increases of 236,000, 177,000 and 1,086,000 metric tons, respectively, from Canada, Australia, and Argentina.

Table 7 presents the results of the second scenario in which importers are price responsive. In this case, the U.S. export price rises

[10] We implicitly assume that the quotas are imposed at the beginning of the export marketing year. If imposed in the course of the year, external and internal prices would be the same until controls were imposed. Subsequently, prices would diverge. If the latter situation were the case, the estimates presented would overstate the price effects in the domestic market and understate the effects in the world market.

Table 6. Simulated Exports of Wheat, 1972–73, Scenario 1, with U.S. Global Export Quota of 26 Million Metric Tons

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	5,538					5,538	190.9
PRC		3,951	1,338			5,289	193.8
Other Asia			7,050		5,436	12,486	194.8
USSR	9,919	5,329				15,248	188.9
E. Europe	1,143					1,143	186.1
EEC		5,890				5,890	184.8
Other W. Europe		1,222				1,222	188.2
Africa	6,146					6,146	189.5
Other S. America	3,254			2,984		6,238	188.9
Total	26,000	16,392	8,388	2,984	5,436	59,200	
Export price (U.S. $/metric ton)	177.5	177.3	182.2	181.4	180.7		

Table 7. Simulated Exports of Wheat, 1972–73, Scenario 2 with U.S. Global Export Quota of 26 Million Metric Tons

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	5,538					5,538	107.78
PRC		3,217	2,072			5,289	110.68
Other Asia			6,153		5,436	11,589	111.68
USSR	9,404	5,844				15,248	105.78
E. Europe	1,143					1,143	102.98
EEC		5,890				5,890	101.68
Other W. Europe		1,222				1,222	105.08
Africa	5,825					5,825	106.38
Other S. America	4,090			1,979		6,069	105.78
Total	26,000	16,173	8,225	1,979	5,436	57,813	
Export price (U.S. $/metric ton)	94.38	94.18	99.08	99.28	97.58		

only from $87.70 to $94.40, rather than to $177.50 when no importers are price responsive. Table 8 illustrates the effect of U.S. imposition of export controls when all other countries in the market are assumed to be price responsive. Relative to the prices observed in table 3, the prices here rise only slightly.

The parametric change in the level of U.S. exports permits calculation of the arc elasticity of excess demand over the range from 26 million to 27.5 million metric tons. It equals −0.053 in scenario 1, the basic specification in which no importing countries respond to price. By making only the three less-developed-country importing regions price responsive, in scenario 2, the arc elasticity of excess demand confronted by the United States rises to −0.71 over the same range of export quantities. When all exporting and importing regions are made price responsive, the implicit arc price elasticity of excess demand confronted by the United States is −2.48 in scenario 3. As the excess demand confronted by the United States becomes more price elastic, the percentage increase in the price necessary to clear the world market falls. These results suggest that, when trade restrictions that cut the link between domestic and world market are removed, the world market price structure is much more stable in the face of shocks to the system.

The foregoing analysis applies only to the case of global export controls. When specific controls are imposed on exports to certain countries, as has occurred in the case of ex-

Table 8. Simulated Exports of Wheat, 1972–73, Scenario 3 with U.S. Global Export Quota of 26 Million Metric Tons

Destination	Source					Total	Import Price (U.S. $/ Metric Ton)
	U.S.	Canada	Australia	Argentina	EEC		
	1,000 Metric Tons						
Japan	5,701					5,701	92.60
PRC			5,563			5,563	94.90
Other Asia			2,631		11,079	13,710	95.90
USSR	8,014	8,973				16,987	90.60
E. Europe	1,074				545	1,619	87.80
EEC		7,160				7,160	86.50
Other W. Europe					1,667	1,667	89.30
Africa	6,555					6,555	91.20
Other S. America	4,656			1,796		6,452	90.60
Total	26,000	16,133	8,194	1,796	13,291	65,414	
Export price (U.S. $/metric ton)	79.20	79.00	83.30	83.10	81.80		

ports from the United States to the Soviet Union, a reshuffling of trade flows occurs. Marginal changes in equilibrium prices and quantities occur with an accompanying increase in total transportation costs; global welfare is reduced.

Limitations and Conclusions

The price elasticities of the respective excess supply and demand relations determine the magnitude of the effects of shocks to the system.[11] The excess demand equations utilized are synthesized in an admittedly crude fashion. Further econometric evidence is needed on the elasticities of the excess supply or excess demand relations for most of the trading regions before much faith should be put in the absolute magnitudes of the price adjustments obtained.

The foregoing analysis ignores the longer run effects such as would be expected when producers react in the following year to changed relative prices. Another likely important longer run effect arises from the fact that export controls may stimulate importing countries to diversify their sources of supply, even at a higher cost.[12]

The model ignores many institutional aspects of the world wheat market that may exist, such as trade agreements, forward contracts, and political decisions to buy or to embargo a certain country's wheat. Furthermore, wheat is not a perfectly homogeneous commodity as assumed in the model, nor are changes in stocks exogenously determined without reference to the present and expected prices. The model also ignores the fact that the wheat harvest occurs in different parts of the year in the northern and southern hemispheres. All of these factors may affect the pattern of world wheat trade and are not taken into account explicitly in the solution prices in the model. They should be borne in mind when interpreting the results.

The most significant result of this study is the demonstration that greater world market price variability results as more countries prevent world price signals from being reflected across their borders into the domestic market through some form of trade control. As the number of countries whose imports are price responsive increases in the simulation, the percentage increase in world price is smaller in response to a shock, such as U.S. export controls or an unanticipated change in Soviet imports.

Today, many countries of the world are considering creation of commodity agreements or cartels to stabilize the world market in primary commodities. Such policies involve increased government intervention in trade. The results reported here suggest that a movement toward trade liberalization, rather than greater restriction, could contribute substantially towards smoothing out world market price fluctuations. The present study has provided evidence that price movements are magnified if large sectors of the world economy are effectively insulated from changing conditions in the world economy.

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[11] To test the sensitivity of the results to the specific parameter estimates utilized, an alternative set of excess supply equations is synthesized. To do this, a linear equation is passed through the observed export price-quantity point for each country with the following short-run elasticities of excess supply: United States, 0.217; Canada, 0.097; Australia, 0.098; and Argentina, 0.625. With the exception of the United States, these elasticities are all at least twice as large as those employed in the study. Under scenario 1 when the United States imposes a 26 million metric ton export quota, its export price rises 103% in the original specification. With the alternative synthesized excess supply equations, it increases 87%. A set of longer run excess supply equations is synthesized assuming that supply as well as demand adjust to price changes. The following elasticities are assumed: United States, 0.634; Canada, 0.691; Australia, 0.892; and Argentina, 1.393. Using this set of much more elastic excess supply equations, the U.S. export price increases only 19% when the export quota is imposed. While the prices in solution are relatively insensitive to changes in transportation costs, the magnitudes of specific wheat trade flows tend to be sensitive.

[12] Another limitation of the analysis is the implicit assumption that no retaliation occurs on the part of other countries that have some monopoly power in the world market. For example, if the behavior of Canada and the United States in the world wheat market is of a duopoly nature, as suggested by McCalla, Canada might counteract the effect of U.S. export controls in raising the world wheat price by releasing stocks. In this case the United States would achieve its objective of lowering its domestic price, but the world wheat price would not rise as much as suggested above.

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Welfare Implications of Commodity Storage under Uncertainty

Peter Helmberger and Rob Weaver

Intertemporal equilibrium is determined for a competitive market when private inventories are held. Production and storage decisions respond to rational expectations of uncertain prices. Algebraic expressions for gains (losses) to buyers and producers are derived in this context. Competitive equilibrium maximizes gains to society. Government programs that stabilize price either completely or partially generate benefits to producers and losses to buyers relative to competitive equilibrium. Welfare effects are quantified assuming an initial period of abundance and various supply and demand elasticities.

Key words: buffer stocks, commodity storage, price instability, private storage, welfare analysis.

More than thirty years ago, Waugh showed that the consumer is better off with fluctuating prices than if prices are stabilized at or above their simple arithmetic means. Oi, in 1961, constructed a model in which a competitive firm earns greater total returns with unstable prices than with stable prices. These two pioneering works caused a modest stir in the economics profession and have given rise to a growing body of literature. Massell creates a linear model in which the Waugh and Oi results are shown to be special cases. Turnovsky correctly points out that much of the previous work is concerned with price variability, not price uncertainty. His models reflect a recursive system in which farm production decisions are made prior to the time when prices are known. More recently, Subotnik and Houck (1976) analyze the implications of stabilizing nonprice endogenous variables.

The main objective of this literature is to deduce the welfare implications of stabilization for producers, consumers, and society as a whole. A common approach is to compare market performance with no storage with performance when storage is used to stabilize price or some other variable.[1] It is fair to say that in much of this literature, including the works cited above, the existence of a private storage industry growing out of the quest for expected profits in an uncertain world is simply abstracted away.

The relevance of models that ignore private storage may be seriously questioned. Neither zero storage nor complete price stabilization is consistent with a competitive storage market. Thus, the analytical results shed little light on actual market situations. Furthermore, although one might conceive of a government buffer stock scheme in which the objective is price stabilization, it makes little sense to compare the resulting performance with that associated with zero storage. Clearly, such comparisons violate the with-and-without government principle conventionally employed in program analysis.

This article is concerned with modeling a competitive pricing system for a storable commodity produced and marketed under conditions of uncertainty. Various government buffer stock (stabilization) schemes are also considered. The major objectives are to evaluate for various groups of market participants the benefits and costs generated by a competitive storage industry and to show how these benefits and costs are affected by alternative government programs. Rough quantitative estimates of various welfare effects are provided.

Peter Helmberger is a professor in the Department of Agricultural Economics, University of Wisconsin, Madison, and Rob Weaver is an assistant professor, Pennsylvania State University.

[1] This approach is also characteristic of a growing body of empirical research (Cochrane and Danin; Reutlinger; Walker, Sharples, and Holland).

Competitive Storage under Conditions of Uncertainty

Because of the recursive nature of grain production, the quantity produced in crop year t depends on expected price at planting time (P^*_t). Quantity demanded for consumption depends on the current price. Thus,

$$(1) \qquad D_t = \alpha_0 - \alpha_1 P_t + U_t$$
$$S_t = \beta_0 + \beta_1 P^*_t + V_t,$$

where D and S equal the quantities demanded and supplied, P equals market price, and U and V are independent, random variables.[2] The expected values of the random variables, $E(U_t)$ and $E(V_t)$, equal zero. Following Muth, it is assumed that $E(P_t) = P^*_t$. This model is similar to those analyzed by Massell, Turnovsky, and Subotnik and Houck (1976) in which the possibility of private storage is ignored.

With a storage industry, however, the clearing of the market implies

$$(2) \qquad D_t - S_t - I_{t-1} + I_t = 0,$$

where I_{t-1} is the carryin and I_t is the carryout. Taking the expectation of equation (2) yields

$$(3) P^*_t = \frac{1}{\alpha_1 + \beta_1} (\alpha_0 - \beta_0 - E(I_{t-1}) + E(I_t)).$$

From equation (3), the value of P^*_t is immediately determinate for all t in the absence of storage. With storage, the values of P^*_t, $E(I_{t-1})$, and $E(I_t)$ are determined simultaneously; competitive equilibrium in period t is affected, potentially at least, by market performance in all past periods and by expected performance in all future periods.

It is convenient to begin through analysis of a special case. Consider the first period, assuming that $I_0 = 0$. It follows that $E(I_1) = 0$ and

$$(4) \qquad P^*_1 = P^* = \frac{\alpha_0 - \beta_0}{\alpha_1 + \beta_1}.$$

To prove this, assert $E(I_1) > 0$. This implies that P^*_1 is larger than P^* and that P^*_2 is less than P^* given expected demand and supply for the first two periods. But if $P^*_1 > P^*_2$, there would be no motivation for storage from the first to the second period. The assertion that $E(I_1) > 0$ leads to an inconsistency. We consider subsequently the case where $I_0 \geq 0$ and $E(I_1) \geq 0$. Under the latter conditions, there is the possibility that P^*_1 is determined through equating the expected demand and supply for storage rather than for consumption and production.

Actual demand (DD_1) and supply (SS_1) in the first period are given in figure 1. Since $P^*_1 = P^*$, Q_{12} is produced. Algebraically,

$$(5) \qquad S_1 = Q_{12} = \frac{\beta_0\alpha_1 + \beta_1\alpha_0}{\alpha_1 + \beta_1} + V_1$$

If $I_1 = 0$, then price sinks to P_{10} given by the intersection of DD_1 and the vertical dashed line Q_{12}, and $P^*_2 = P^*$ just as in the first period prior to planting. Let T equal the per unit cost of storage for one period and assume that T is constant for all storage levels. If $P^* - P_{10} > T$, then positive expected profit is consistent with a sufficiently small carryout.

Assuming risk neutrality, pure competition, and no barriers to entry, equilibrium requires[3]

$$(6) \qquad (P^*_t - (t-1)T) \leq P_1 \text{ for } t > 1.$$

In particular, if $P^* - P_{10} > T$, competition results in a level of storage such that $P^*_2 - T = P_1$; expected profit equals zero. Finding the competitive level of storage requires derivation of a supply and a demand function for storage. The intersection of these two func-

[2] The stochastic term affecting domestic supply (V_t) may be given the standard justification of arising from the occurrence of natural phenomena and random errors in decision making. By recognizing that D_t may be interpreted as the sum of domestic and foreign demand for grain, U_t may be thought of as following in part from shocks to foreign supplies of grain.

[3] Discounting and risk premiums, in the case of risk aversion, are ignored to keep the argument simple, but the analysis can be generalized to include these complicating factors.

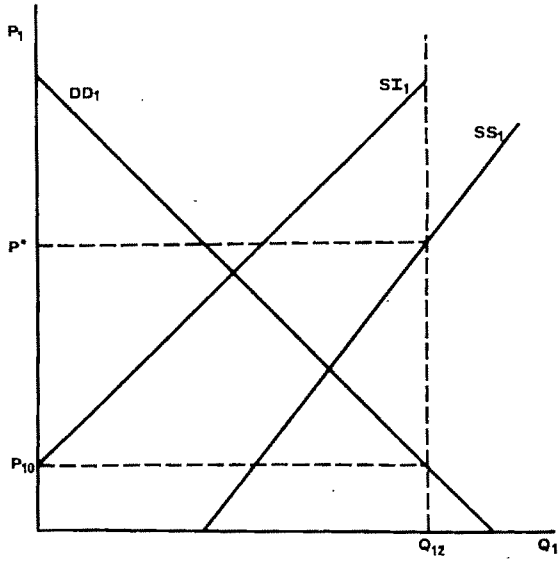


Figure 1

tions yields competitive equilibrium. If $P^* - P_{10} < T$, then no storage occurs, and the intersection of DD_1 and SS_1 gives competitive equilibrium.

Let I_{s1} equal the quantity supplied for storage in the first period. By definition, $I_{s1} = Q_{12} - D_1$. The supply function for storage may be derived by making the relevant substitutions. Thus,

$$(7) \qquad I_{s1} = \alpha_1 P_1 + Q_{12} - \alpha_0 - U_1.$$

In figure 1, the supply curve for storage is derived graphically by simply subtracting laterally DD_1 from the vertical dashed line above Q_{12} and is labeled SI_1.

To derive the competitive demand for storage, let i_{1t} equal the quantity of storage undertaken in the first period and planned for expected delivery in the tth period for $t > 1$. Let I_{d1} equal the total quantity demanded for storage in the first period. By definition, $I_{d1} = i_{12} + i_{13} + i_{14} + \ldots$. Positive storage in the first period drives down the expected price in the second and, possibly, subsequent periods. Moreover, lower first period prices encourage storage for planned delivery in a successively larger number of periods.

Consider a set of potential prices in the first period such that $P^* - 2T \leq P_1 < P^* - T$. Positive profit can be expected from at least a limited amount of storage for planned delivery in the second period but not for delivery in the third and subsequent periods. (Competition would, of course, push storage to such a level that expected profit is driven to zero.) Further, the lowest price in the set under consideration, $P_1 = P^* - 2T$, is a "switch" price in that if P_1 falls below $P^* - 2T$ then storage for delivery in both the second and third periods becomes consistent with positive expected profits.

If $P^* - 2T \leq P_1 < P^* - T$, then using the above arguments $I_{d1} = i_{12}$ and $i_{1t} = 0$ for all $t \geq 3$. Moreover, if $P^*_2 = P^*$, then expected supply and demand quantities are equal for the second period, and there is no demand for storage. Falling expected prices in the second period cause the difference between expected quantity demanded and expected quantity supplied to grow even larger. It is this gulf between expected demand and expected supply that creates a demand for storage in the first period. Thus, $I_{d1} = i_{12} = E(D_2) - E(S_2)$. By substitution,

$$(8) \qquad I_{d1} = \alpha_0 - \beta_0 - (\alpha_1 + \beta_1)P^*_2.$$

Zero expected profit from positive storage implies that $P^*_2 - T = P_1$. Therefore, the demand for storage in the first period for planned delivery in the second period only is given by[4]

$$(9) \qquad I_{d1} = \alpha_0 - \beta_0 - (\alpha_1 + \beta_1)(P_1 + T) \quad \text{for } P^* - 2T \leq P_1 < P^* - T.$$

A graphical derivation of equations (8) and (9) is given in figure 2. Expected demand and supply, $E(DD_2)$ and $E(SS_2)$, are given in the second quadrant. The graph of equation (8),

[4] The function (9) holds only for $I_{d1} \leq \bar{i}_{12}$, where $\bar{i}_{12}$ is the specific value for I_{d1} when $P_1 = P^* - 2T$.

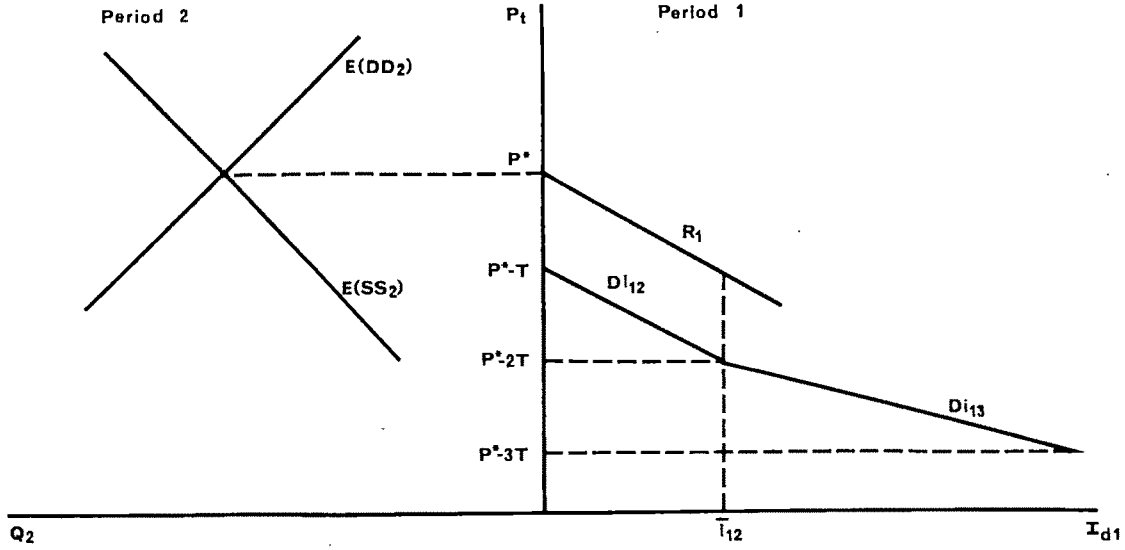


Figure 2

R_1, is obtained by subtracting laterally $E(SS_2)$ from $E(DD_2)$ for prices less than P^* and plotting the positive differences in the first quadrant. The graph of equation (9), Di_{12}, is obtained by subtracting vertically T from R_1 and taking into account the restrictions on its range of applicability.

Considering the range of prices $P^* - 3T \leq P_1 < P^* - 2T$, storage for planned delivery in the second and third periods, but not beyond, is consistent with positive expected profit. Moreover, $P_1 = P^* - 3T$ becomes the new switch price in that a lower price would give rise to planned expected storage for at least the first three periods beyond the first. Given the price range here considered, $I_{d1} = i_{12} + i_{13}$. Therefore, $I_{d1} = E(D_2) - E(S_2) + E(D_3) - E(S_3)$. Zero expected profit implies that $P_1 = P^*_2 - T = P^*_3 - 2T$. Making the relevant substitutions[5]

$$(10)\quad I_{d1} = 2(\alpha_0 - \beta_0) - 2(\alpha_1 + \beta_1)P_1 - 3(\alpha_1 + \beta_1)T \text{ for } P^* - 3T \leq P_1 < P^* - 2T.$$

The graph of equation (10), Di_{13}, is given in figure 2. The slope of Di_{13} is greater algebraically than is the slope for Di_{12}. Thus, the demand for storage is "kinked" at $P_1 = P^* - 2T$.

These results can be generalized for the case where storage from the first period is planned for expected delivery in each of $n - 1$ subsequent periods. Thus,

$$(11)\quad I_{d1} = (n-1)(\alpha_0 - \beta_0) - (n-1)(\alpha_1 + \beta_1)P_1 - (\alpha_1 + \beta_1)T\sum_{2}^{n}(t-1)$$

$$\text{for } P^* - (n-1)T \leq P_1 < P^* - (n-2)T.$$

In sum, the demand for storage in the first period (assuming $I_0 = 0$) is a kinked function consisting of a finite number of linear functions each restricted to its own range of values. If storage occurs, the competitive equilibrium is given by $I_{s1} = I_{d1} = I_1$. The equilibrium can be found graphically or algebraically using trial-and-error methods. The resulting model can be used to generate a large number of internally consistent hypotheses as to the impacts of exogenous changes on price, quantity consumed, and quantity stored in the first period as well as on the expected values for prices and quantities consumed, produced, and stored in all future periods. Examples of exogenous change include structural shifts in demand and/or supply, changes in storage costs, and weather anomalies both in the United States and abroad.

We now relax the assumption that $I_0 = 0$ and show how P^*_1 can be determined at planting time when $I_0 \geq 0$. Let $E(C_1)$ equal the expected total supply in the first period, consisting of expected supply plus the carryin I_0. Through substitution,

$$(12)\quad E(C_1) = \beta_0 + \beta_1 P^*_1 + I_0.$$

The graphs of expected demand and expected supply in the first period, $E(DD_1)$ and $E(SS_1)$, are given in figure 3. The graph of the expected demand for storage, $E(DI_1)$, is the same as for the demand for storage, since the latter has no stochastic elements. The graph of equation (12) for a specific value of I_0, $I_0 = I_{01}$, is given by $E(AS_1)$. The supply for storage in the first period is the modification of equation (7) given by

$$(13)\quad I_{s1} = \alpha_1 P_1 - \alpha_0 + \beta_0 + \beta_1 P^*_1 + V_1 - U_1 + I_0.$$

The expected supply for storage, $E(SI_1)$, is also given in figure 3, assuming $I_0 = I_{01}$. An increase (decrease) in I_0 shifts $E(AS_1)$ and $E(SI_1)$ to the right (left). For all values of $I_0 \leq I_{01}$, $E(SI_1)$ lies above $E(DI_1)$ for positive levels of storage; expected competitive equilibrium is given by the intersection of $E(DD_1)$ and $E(AS_1)$. Therefore,

$$(14)\quad P^*_1 = \frac{1}{\alpha_1 + \beta_1}(\alpha_0 - \beta_0 - I_0) \text{ for } I_0 \leq I_{01}.$$

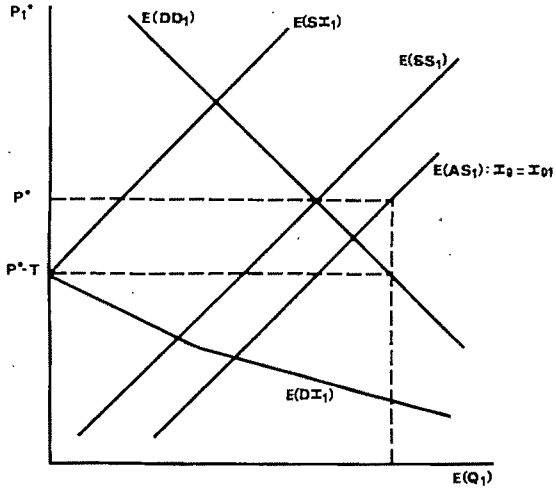


Figure 3

[5] The function (10) holds only for $\bar{i}_{12} < I_{d1} \leq \bar{i}_{12} + \bar{i}_{13}$, where $I_{d1} = \bar{i}_{12} + \bar{i}_{13}$ when $P_1 = P^* - 3T$ and where $\bar{i}_{12}$ is as defined previously.

For all values of $I_0 > I_{01}$, P^*_1 is determined by the expected demand and expected supply for storage. As noted, the latter shifts to the right with increases in I_0, whereas the former is stationary. Thus, P^*_1 can be determined for every possible level of I_0. Once P^*_1 is determined, the previous analysis of competitive storage is applicable with minor modification.

In order to gain some insights as to the quantitative significance of competitive storage, average grain disappearance in United States in recent crop years is assumed to be "normal" production and consumption. Over the period 1969–70 through 1975–76, average grain disappearance (wheat, corn, sorghum, oats, and barley) equaled roughly 9 billion bushels. The weighted average price deflated for price level changes for farm inputs (1967 = 100) was \$1.24 per bushel. Given the elasticities of demand and supply for the "normal" situation, α_0, α_1, β_0, and β_1 can be calculated. Although definitive estimates of the elasticities are not available, various ballpark estimates may be considered in a sensitivity analysis. The supply elasticities (E_s) considered are 0, 0.2, 0.4, 0.6, and 0.8. Demand elasticities (E_d) considered equal −0.2, −0.4, −0.6, and −0.8. The storage cost T is set equal to 0.186¢ per bushel, which equals 15% of the normal grain price (see Jones). In order to consider a year of substantial abundance, U_1 is set equal to −1.8 billion bushels (20% less than normal) and V_1 is set equal to 1.8 billion bushels (20% more than normal). Given these circumstances, the competitive levels of price and storage of the first period are given in table 1.

Table 1. Estimated First Period Grain Prices (P_1) and Quantities Stored (I_1)

Elasticity of Demand	Elasticity of Supply 0	0.2	0.4	0.6	0.8
	Billions \$				
$E_d = -0.2$					
P_1(¢/bu.)	0.372	0.567	0.657	0.717	0.761
I_1 (billion bu.)	2.338	2.623	2.754	2.837	2.904
$E_d = -0.4$					
P_1 (¢/bu.)	0.651	0.721	0.769	0.801	0.824
I_1 (billion bu.)	1.890	2.092	2.232	2.325	2.392
$E_d = -0.6$					
P_1 (¢/bu.)	0.778	0.812	0.835	0.851	0.864
I_1 (billion bu.)	1.590	1.735	1.835	1.908	1.964
$E_d = -0.8$					
P_1 (¢/bu.)	0.847	0.864	0.880	0.896	0.909
I_1 (billion bu.)	1.320	1.414	1.512	1.602	1.680

Note: See text for explanation and interpretation.

These estimates suggest a number of important conclusions. First, a competitive storage industry does not forestall large swings in grain prices. If $E_s = |E_d| = 0.4$, for example, the first period price (77¢) only amounts to 62% of that expected (\$1.24). Such deviations between actual and expected prices would likely cause considerable financial stress among farmers and the farm finance establishment. Second, differences between expected and actual prices are found to be much greater in the absence of competitive storage. For example, if $E_s = |E_d| = 0.4$, price in the absence of storage drops to zero. Third, as one might suppose, greater elasticities in demand and supply both act to reduce differences between expected and actual prices. Finally, storage levels are quite sensitive to elasticities, ranging from 12% to 32% of normal production.[6]

Benefit-Cost Analysis of Competitive Storage

Consider competitive equilibrium in the first period assuming that storage occurs ($I_1 > 0$) for planned expected delivery in each of $n - 1$ future periods and that $I_0 = 0$. Under these conditions, storage tends to enhance price in the first period and lower expected prices in each of the $n - 1$ future periods. Farm producers are made better off in the first period but can expect to lose benefits in future periods. Buyers, on the other hand, are made worse off in the first period but can expect gains in future years. On balance are farm producers made better off because of storage? Are buyers made better off? What level of storage maximizes the net gains to society?

In considering these questions, recall that competitive equilibrium at the first period yields determinate values for i_{1t}. By definition, $E(I_t) - E(I_{t-1}) = -i_{1t}$.[7] Using this result plus equation (3),

$$(15) \quad P^*_t = \frac{1}{\alpha_1 + \beta_1}(\alpha_0 - \beta_0 - i_{1t}) \quad \text{for } t > 1.$$

[6] In most cases, future deliveries are planned for three years or less. This plus a liberal estimate of storage cost suggest that introduction of the discount apparatus would not seriously alter our empirical results.

[7] In the first period $E(I_t) = i_{1(t+1)} + i_{1(t+2)} + \ldots$ and $E(I_{t-1}) = i_{1t} + E(I_t)$.

Let $P^*_t = P^*$ when $i_{1t} = 0$. Let $P^*_t = P^*_{tc}$ when $i_{1t} > 0$.

In figure 4, the expected demand and supply functions are given by $E(DD_t)$ and $E(SS_t)$. The area given by b measures the expected loss to producers in the tth period because i_{1t} lowers expected price from P^* to P^*_{tc}. The area $a + b$ measures expected gains to buyers. We take as the producer gain the sum of the certain gain in period one and the total expected losses from the $n - 1$ future periods. The buyer gain, on the other hand, equals the certain loss in period one plus the expected gains in the $n - 1$ future periods. The entrepreneurs in the storage industry, hereafter referred to as the arbitrageurs, earn no profit with zero storage and zero expected profit from competitive equilibrium. Explicit treatment of the gains to the arbitrageurs is nonetheless necessary in considering the net gains from storage to society as a whole.

Gains to Producers

Since first period production costs have already been incurred, producer benefits in the first period may be measured by total receipts. Let W_{P1} equal the gain in first period benefits arising out of storage, then

$$(16)\quad W_{P1} = (P_1 - P_{10})S_1 = \frac{\beta_0\alpha_1 + \beta_1\alpha_0 + V_1}{\alpha_1(\alpha_1 + \beta_1)} I_1,$$

where P_{10} equals price with zero storage and other variables are as defined previously. In this and subsequent discussion of producer and consumer gains, all endogenous variables such as S_1, P_1, and I_1 are considered equal to their competitive equilibrium values.[8]

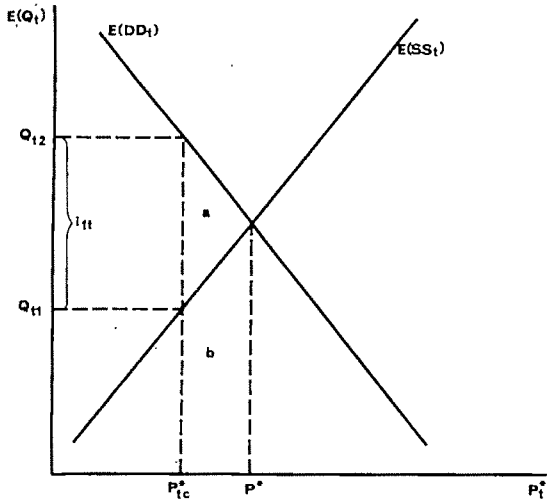


Figure 4

Let $E(W_{Pt})$ equal the expected producer loss of benefits in the tth period, then $E(W_{Pt})$ is given by the definite integral of the expected supply function in the tth period with $P^*_t = P^*_{tc}$ and $P^*_t = P^*$ the lower and upper limits, respectively. Hence, the area b in figure 4 is given by

$$(17)\quad E(W_{Pt}) = \frac{\beta_0\alpha_1 + \beta_1\alpha_0}{(\alpha_1 + \beta_1)^2} i_{1t} - \frac{\beta_1}{2(\alpha_1 + \beta_1)^2} i_{1t}^2.$$

Let $E(W_p)$ equal the producer gain in the first period minus expected losses in all subsequent $n - 1$ periods. Then

$$(18)\quad E(W_p) = W_{p1} - \sum_2^n E(W_{pt}) = \frac{\beta_1(\beta_0\alpha_1 + \beta_1\alpha_0) + (\alpha_1 + \beta_1)V_1}{\alpha_1(\alpha_1 + \beta_1)^2} I_1 + \frac{\beta_1}{2(\alpha_1 + \beta_1)^2} \sum_2^n i_{1t}^2.$$

If $V_1 \geq 0$ or if $V_1 < 0$ and $(|V_1|) \leq \beta_1(\beta_0\alpha_1 + \beta_1\alpha_0)/(\alpha_1 + \beta_1)$, then quasi rents to producers increase with storage. If demand is stable ($U_1 = 0$) and supply is unstable, storage occurs only if $V_1 > 0$. Under these circumstances, producers gain from competitive storage. If supply is stable ($V_1 = 0$) and demand is unstable, storage occurs only if $U_1 < 0$. Under these circumstances, producers also gain.

In figure 5, U_1 and V_1 are plotted on the vertical and horizontal axes, respectively. In the absence of storage $P_1 = P^* + (U_1 - V_1)/\alpha_1$. Storage only occurs if $P^* - P_1 > T$ or if $-(U_1 - V_1)/\alpha_1 > T$. These inequalities exist for any point below the graph of $U_1 = V_1 - T\alpha_1$ given by L in figure 5. Using equation (18) and figure 5, producers can expect to gain from storage for any point below L and in the first and fourth quadrants including the axes. It is only in the case of a point below L and within the third quadrant that the sign of $E(W_P)$ is incon-

[8] Although all endogenous variables may be expressed as functions of exogenous variables and of the stochastic terms, we shall for simplicity express welfare measures in terms of endogenous inventories. The fact that U_1 does not appear explicitly in equation (18) should not be taken to mean that U_1 has no effect on welfare gains (losses).

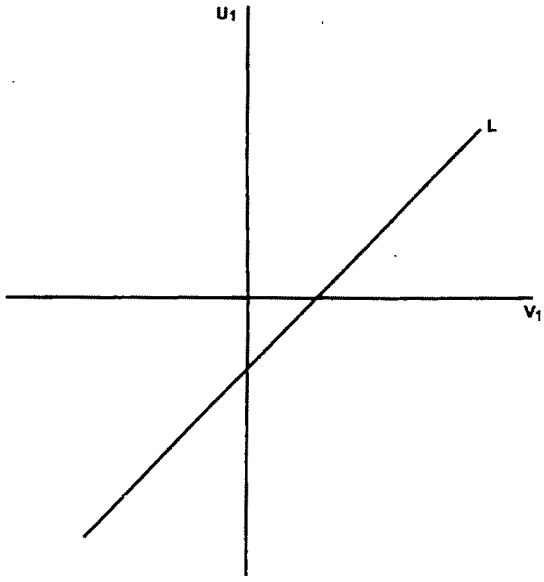


Figure 5

clusive in the absence of quantitative information. This leads to an important conclusion. Whether prior to planting time producers can expect to gain (lose) from competitive storage depends in part on the joint probability density function for U_1 and V_1. For example, if storage in practice almost always occurs because of large values of V_1, with U_1 close to zero, then it is likely that producers prior to planting in the first period could expect to gain from the existence of a competitive storage industry.

Gains to Buyers

The demand for consumption as conceptualized here is a derived demand. If the marketing margin (the difference between retail and farm gate price) is a constant, then the area to the left of the derived demand and between any two price lines gives a correct measure of Marshallian consumer surplus. Within the confines of a short-run model, however, it is unrealistic to assume a constant marketing margin. It is assumed here that the "marketing" industry, which includes the livestock sector, has the appropriate levels of fixed assets and fixed costs consistent with expected retail demand and farm output supply. The increase in marketings above normal therefore entails intensification on fixed plants and increasing marginal costs for the provision of marketing services.

In figure 6, let DD_t equal the derived demand as before. The curve S_{mt} shows the margin required to market alternative levels of Q_t. The retail demand is given by RRD_t. Subtracting S_{mt} from RRD_t vertically yields DD_t. The area to the left of the derived demand and between any two price lines equals the sum of Marshallian consumer surplus and quasi rents to the marketing sector. Thus, the shaded area, hereafter referred to as buyer benefits (losses), equals the sum of the crosshatched areas.

Let W_{b1} equal the loss in the first period caused by competitive storage. Then W_{b1} is given by the definite integral of the first period demand function with P_{10} and P_1 the lower and upper limits, respectively:

$$(19)\quad W_{b1} = \frac{\beta_0\alpha_1 + \beta_1\alpha_0 + V_1}{\alpha_1(\alpha_1 + \beta_1)} I_1 - \frac{1}{2\alpha_1} I_1^2.$$

Let $E(W_{bt})$ equal the expected gain in buyer benefits in the tth period. Then $E(W_{bt})$ is given by the definite integral of the expected demand function in the tth period with $P^*_t = P^*_{t0}$ and $P^*_t = P^*$ the lower and upper limits, respectively:

$$(20)\quad E(W_{bt}) = \frac{\beta_0\alpha_1 + \beta_1\alpha_0}{(\alpha_1 + \beta_1)^2} i_{1t} + \frac{\alpha_1}{2(\alpha_1 + \beta_1)^2} i_{1t}^2.$$

Let $E(W_b)$ equal the total expected buyer gains in periods beyond the first minus the loss in the first, then

$$(21)\quad E(W_b) = \sum_2^n E(W_{bt}) - W_{b1} = -\frac{\beta_1(\beta_0\alpha_1 + \beta_1\alpha_0) + (\alpha_1 + \beta_1)V_1}{\alpha_1(\alpha_1 + \beta_1)^2} I_1 + \frac{1}{2\alpha_1} I_1^2 + \frac{\alpha_1}{2(\alpha_1 + \beta_1)^2} \sum_2^n i_{1t}^2.$$

If $V_1 < 0$ and $(|V_1|) > \beta_1(\beta_0\alpha_1 + \beta_1\alpha_0)/(\alpha_1 + \beta_1)$, then buyers gain from storage. If $V_1 \geq 0$, it becomes difficult to determine the sign of $E(W_b)$. As in the case of producer benefits, whether prior to planting time buyers can expect to gain (lose) from competitive storage depends on the joint probability density function for U_1 and V_1.

Economic Efficiency

Though arbitrageurs cannot expect gains from competitive storage, they could expect gains (or losses) from noncompetitive storage

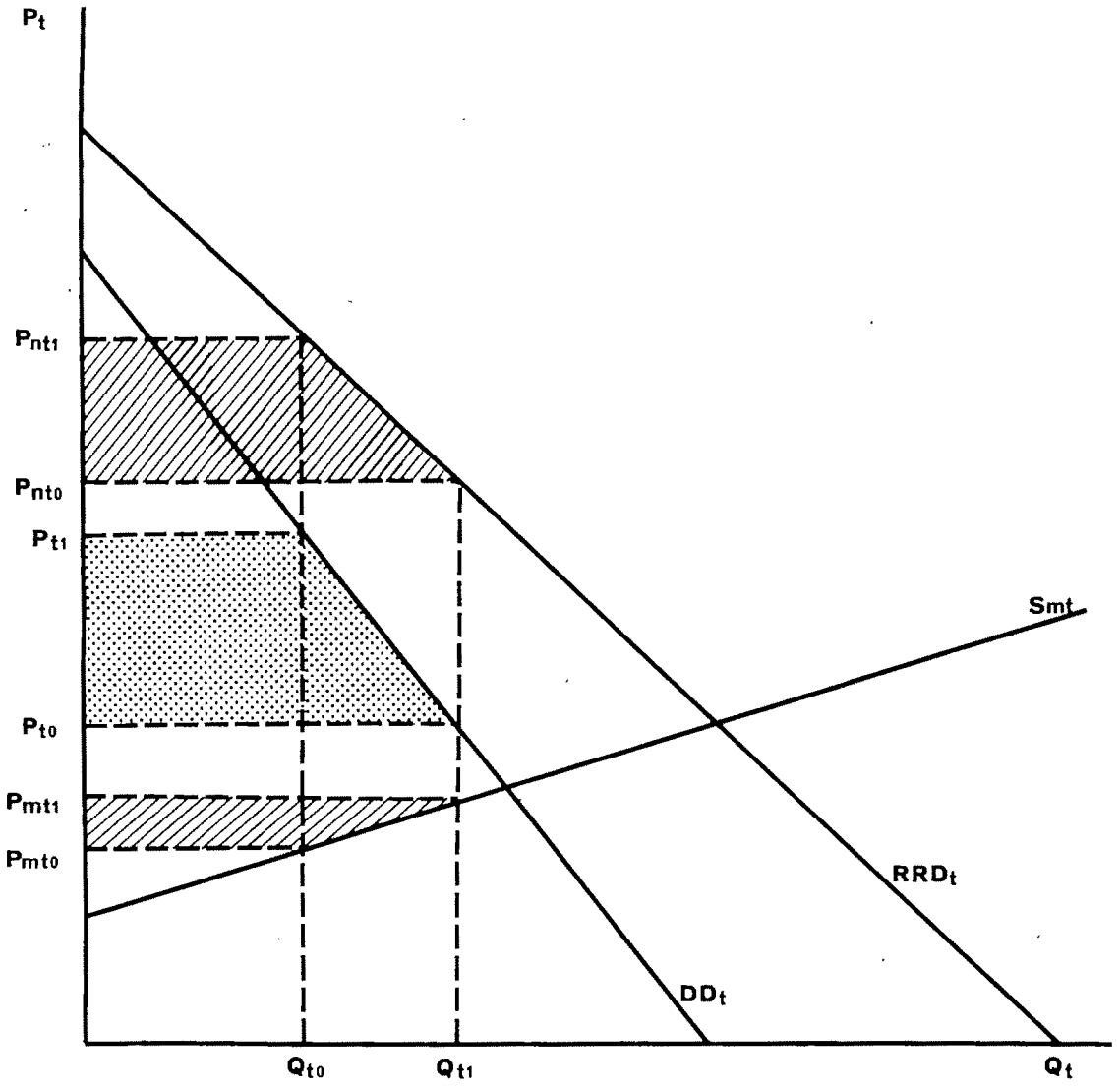


Figure 6

levels. Dropping the assumption that all endogenous variables are in equilibrium necessitates including explicitly the gains to arbitrageurs in measuring the net gains to society from alternative storage levels. Let W_s equal gains to arbitrageurs. By definition,

$$(22) \quad W_s = \sum_{2}^{n} (P_t - P_1 - (t-1)T)i_{1t}.$$

Making the relevant substitutions and taking the expectation,

$$(23) \quad E(W_s) = \frac{\alpha_0 - \beta_0}{\alpha_1 + \beta_1} I_1 - \frac{1}{\alpha_1 + \beta_1} \sum_{2}^{n} i_{1t}^2 - \frac{I_1^2}{\alpha_1} - \sum_{2}^{n} (t-1)Ti_{1t}.$$

The expected gains to producers, buyers, and arbitrageurs taken together are given by $E(W) = E(W_p) + E(W_b) + E(W_s)$ (externalities are assumed to be absent). Maximizing $E(W)$ with respect to i_{1t} subject to the constraint that $I_1 = i_{12} + i_{13} + \ldots + i_{1n}$ requires

$$(24) \quad i_{12} = i_{1t} + (t-2)(\alpha_1 + \beta_1)T \quad \text{for } 3 \leq t \leq n.$$

Using the $n - 2$ relations given by equation (24) plus the constraint $I_1 = i_{12} + i_{13} + \ldots + i_{1n}$ allows solving for i_{1t} in terms of I_1 for $2 \leq t \leq n$. Thus, for example,

$$(25) \quad i_{12} = \frac{I_1}{n-1} + \frac{\alpha_1 + \beta_1}{n-1} T \sum_{1}^{n-2} t.$$

Expressing i_{1t} in terms of I_1 allows writing $E(W)$ as a function of I_1 only. Maximizing $E(W)$ yields an algebraic expression for I_1 that is exactly the same as that obtained by solving the supply and derived demand for storage for I_1. Thus, the maximization of $E(W)$ yields a solution for I_1 and, therefore, P_1 that equals the competitive equilibrium values. Moreover, using the $n - 2$ equations given by equations (24) plus (15) yields

$$(26)\quad P^*_t - P^*_2 = (t - 2)T \text{ for } 3 \leq t \leq n.$$

Finally, since I_1 and P_1 equal competitive equilibrium values, equation (11) may be used together with equations (15) and (25) to show that $P^*_2 = P_1 + T$. Thus, the first-order conditions for the maximization of $E(W)$ are identical to those given by the competitive solution. It can also be shown that the net gain to society is given by the area under the kinky demand for storage and above the supply for storage. Graphically, this area is maximized when storage is at the competitive level.

Estimates of Distributional Impacts

Using the information given in table 1 and related figures, the welfare impacts of competitive storage are calculated for various supply and demand elasticities. The results are given in table 2. The net gains and distributional consequences are sensitive to demand and supply elasticities. Net gains to society range from $275 million to over $3 billion. Gains to producers range from $70 million to over $15 billion. Buyers only gain when supply is perfectly inelastic; otherwise, they lose. Understanding the distributional and efficiency impacts of competitive storage clearly requires precise estimates of supply and demand elasticities. Previous empirical analyses based on a single set of ad hoc elasticity estimates are suspect.

Table 2. Expected Gains to Grain Farmers, Grain Buyers, and Society from Competitive Storage in Comparison with No Storage

Elasticity of Demand	Elasticity of Supply 0	0.2	0.4	0.6	0.8
	Billion $				
$E_d = -0.2$					
Farmers	1.997	9.499	12.461	14.096	15.186
Buyers	0.481	−6.634	−9.408	−10.927	−11.926
Society	2.478	2.865	3.053	3.169	3.260
$E_d = -0.4$					
Farmers	0.404	2.556	3.830	4.673	5.272
Buyers	0.517	−1.513	−2.708	−3.493	−4.048
Society	0.921	1.043	1.222	1.180	1.224
$E_D = -0.6$					
Farmers	0.151	1.064	1.692	2.152	2.504
Buyers	0.322	−0.539	−1.127	−1.554	−1.878
Society	0.473	0.525	0.565	0.598	0.626
$E_d = -0.8$					
Farmers	0.070	0.525	0.879	1.168	1.408
Buyers	0.205	−0.221	−0.551	−0.820	−1.043
Society	0.275	0.304	0.328	0.348	0.365

Note: See text for explanation and interpretation.

Benefit-Cost Analysis of Government Stabilization Programs

Three government stabilization programs are analyzed. Under the first, the government seeks to stabilize price at P^*. Under the second, the government establishes upper and lower limits on price but allows price to vary freely between those limits. The third program involves stabilization of quantity purchased. For complete and partial price stabilization, our objective is to assess the gains (or losses) to buyers and sellers under the program in comparison with competitive storage. The government is assumed to have no initial stocks.

Complete Price Stabilization

Obviously, the government is not able to stabilize price at P^* after harvest in the first period if it has no initial stocks and P_1 is larger than P^*. Of interest here is a period of abundance, the first, say, which requires the government to acquire stocks in order to force the price up to P^*. The demand for storage on the part of the government (D_{g1}) becomes perfectly elastic at the price P^* (figure 7).[9] The level of government storage equals Q_{13} and is found by the intersection of D_{g1} with the supply for storage (SI_1). The demand for storage on the part of private traders (DI_1) is no longer relevant in explaining storage levels. Traders only undertake storage if the expected price in the second period is larger than or equals $P_1 + T$.

Turning to welfare analysis, it is important to recognize that the expected price in future periods is above P^*. This is true because the government, in the absence of a budget constraint, can always assure a price no less than P^* but, because of limited stocks, cannot

[9] The specific prices and quantities given in figure 7 are not to be confused with those given in previous figures.

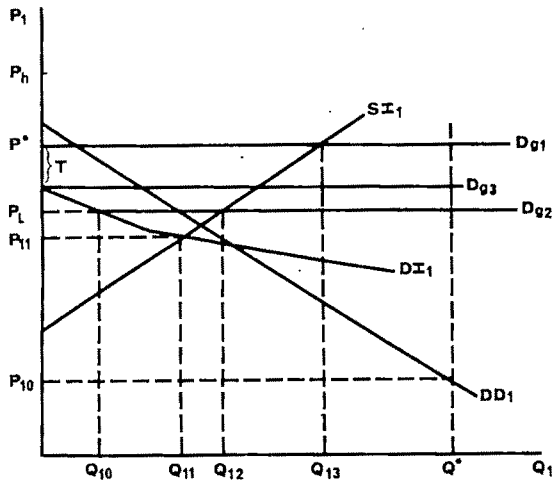


Figure 7

guarantee that price will not rise above P^*. This asymmetry poses serious theoretical complications. In what follows, these complications are avoided by assuming that the expected price in future periods is P^* and developing expressions for what might be called the minimum gain in producer benefits and the maximum consumer loss. The bias in the resulting estimates decreases as government stocks acquired in the first period increase.

In figure 7 the competitive price is P_{11} given by the intersection of SI_1 and DI_1. The first period gain in producer benefits equals $(P^* - P_{11})S_1$. Additional expected gains accrue to producers, however, because the expected losses from expected competitive deliveries in future periods are avoided. Let $E(W_{pg})$ equal the minimum expected gains to producers from complete price stabilization. Then,

$$(27)\quad E(W_{pg}) = (P^* - P_{11})S_1 + \frac{\beta_0\alpha_1 + \beta_1\alpha_0}{(\alpha_1 + \beta_1)^2} I_1 - \frac{\beta_1}{2(\alpha_1 + \beta_1)^2} \sum_{2}^{n} i_{1t}^2.$$

The last two terms on the right-hand side come from summing equation (17) over t. The conclusion is that producers gain from the government policy.

Turning to buyers, the buildup of stocks in the first period beyond competitive levels drives the first period price up and lowers buyer surplus. Moreover, the complete destruction of competitive storage eliminates the expected gains from lower expected prices in future periods. Thus, the expected gain to buyers is negative.

We maintain the simplifying assumption that expected future prices equal P^*. Letting $E(W_{bg})$ equal the maximum expected buyer losses from complete price stabilization,

$$(28)\quad E(W_{bg}) = (\alpha_0 + u_1)(P^* - P_{11}) - \frac{\alpha_1}{2}(P^* - P_{11})^2 + \frac{\beta_0\alpha_1 + \beta_1\alpha_0}{(\alpha_1 + \beta_1)^2} I_1 + \frac{\alpha_1}{2(\alpha_1 + \beta_1)^2} \sum_{2}^{n} i_{1t}^2.$$

The last two terms on the right-hand side are obtained by summing equation (20) over t.

Without going into detail, it follows from previous analysis that economic efficiency is sacrificed by the acquisition of stocks beyond the competitive level. Competitive storage implies that a bountiful year gives rise to increased expected consumption and reduced expected production, relative to normal levels, in future years. Complete price stabilization destroys these effects. This explains in part the source of inefficiency. The expected monetary gain to the government is negative. Any losses that materialize in fact are presumably made up through increased taxes.

Table 3 provides estimated expected gains to grain farmers and losses to buyers resulting from complete price stabilization. The empirical basis for these estimates is the same as for previous estimates. In particular, $U_1 = -1.8$ and $V_1 = 1.8$. For an initial period of such abundance, the distributional effects appear to

Table 3. Expected Gains to Grain Farmers and Expected Losses to Buyers from Complete Price Stabilization in Comparison with Competitive Storage

Elasticity of Demand	Elasticity of Supply 0	0.2	0.4	0.6	0.8
	Billion $				
$E_d = -0.2$					
Farmers	23.863	15.154	11.692	9.751	8.493
Buyers	22.351	14.108	10.837	9.008	7.818
$E_d = -0.4$					
Farmers	12.220	9.836	8.416	7.477	6.807
Buyers	12.022	9.733	8.358	7.446	6.795
$E_d = -0.6$					
Farmers	8.271	7.270	6.582	6.078	5.692
Buyers	8.821	7.821	7.132	6.628	6.244
$E_d = -0.8$					
Farmers	6.287	5.793	5.402	5.079	4.812
Buyers	7.378	6.868	6.453	6.101	5.807

Note: See text for explanation and interpretation.

be quite significant. For $E_s \leq 0.4$ and $|E_D| \leq 0.4$, a price stabilization program entails a transfer of benefits from buyers to grain producers of over $8 billion. Although the estimated gains and losses are very close, it should not be assumed that the efficiency loss would be of minor importance. The discounted flow of expected future costs associated with holding the government inventory in perpetuity could run into the billions of dollars.

Partial Price Stabilization

While the theoretical literature centers largely on complete price stabilization, proponents of buffer stock schemes have often favored establishment of upper and lower price limits. Let P_H and P_L in figure 7 be the upper and lower price limits, respectively. In this case, the demand for storage (D_{g2}) consists of DI_1 for prices in excess of P_L and becomes perfectly elastic at P_L. This buffer stock scheme drives price up to P_L and lowers private storage from Q_{11} to Q_{10}. Government storage equals $Q_{12} - Q_{10}$. Again, producers gain, consumers lose, and economic efficiency is decreased. Relative to competitive equilibrium, the expected price in the second period and perhaps in other future periods is increased with corresponding consequences for expected production and consumption levels.

The analysis of benefits and costs for this case involves an integration of the analyses for competitive storage and complete price stabilization. The derivation of equations for the welfare effects is straightforward and, to conserve space, is omitted. Continuing the empirical analysis, the gains to grain producers and losses to buyers, in comparison with competitive storage, are given in table 4. Again, $U_1 = -1.8$ and $V_1 = 1.8$. The price floor (ceiling) was set at 99.2¢ per bushel ($1.49 per bushel). As expected, the gains to grain farmers (losses to buyers) fall relative to those given in table 3.

Stabilization of Quantity Purchased

Subotnik and Houck (1976) consider the welfare implications of stabilizing consumption and production as an alternative to stabilizing price. Weaver and Helmberger question whether quantity stabilization on the part of the government is consistent with the existence of a competitive storage industry.[11] The concepts developed above allow a rigorous development of a contraexample in which stabilization of "consumption" (private purchases) is inconsistent with competitive market behavior. The example assumes that first period supply is a bit less than expected and demand is much less than expected such that private storage would occur under competitive conditions. In figure 7, SI_1 and DI_1 have been constructed accordingly.

Assume the government has large initial stocks and adopts a program in which the objective is to stabilize consumption at Q^*, where Q^* is obtained by equating expected demand and expected supply. Since demand is stochastic, stabilization involves price setting via buffer stock transactions. In figure 7, consumption only equals Q^* if the price is driven

Table 4. Expected Gains to Grain Farmers and Expected Losses to Buyers from Price Stabilization in Comparison with Competitive Storage

Elasticity of Demand	Elasticity of Supply 0	0.2	0.4	0.6	0.8
	---------- Billion $ ----------				
$E_d = -0.2$					
Farmers	20.627	11.979	8.641	6.887	5.877
Buyers	15.089	8.379	5.838	4.496	3.672
$E_d = -0.4$					
Farmers	8.984	6.692	5.428	4.705	4.315
Buyers	6.165	4.517	3.592	2.983	2.311
$E_d = -0.6$					
Farmers	5.035	4.158	3.655	3.399	3.324
Buyers	3.469	2.823	2.382	2.062	1.818
$E_d = -0.8$					
Farmers	3.050	2.711	2.538	2.494	2.566
Buyers	2.171	1.859	1.650	1.492	1.363

Note: See text for explanation and interpretation.

[10] Our comment has elicited a reply and extension by Subotnik and Houck (1977) that modifies their original model through postulating a supply for storage equation given by $M_t = \gamma(P^* - P_t)$, where $M_t = I_t - I_{t-1}$. Their claim that the algebraic expressions for the gains to producers and consumers as developed in their original paper are unaffected by the inclusion of the supply for storage equation appears to be in error. Their proposed measure of gains to speculators also appears to be in error. Moreover, Subotnik and Houck claim that their supply for storage equation is supported by Brennan, Peck, and Working. We believe, on the contrary, that the results obtained by Brennan, Peck, Working, Muth, and others are mainly inconsistent with the Subotnik and Houck supply for storage equation. The feasibility of quantity stabilization within the Subotnik and Houck model of private storage is not so much support for the view that quantity stabilization may be operational as it is evidence of an inadequate theory. Interested readers may write to us for an unpublished note containing our arguments and proofs.

down to P_{10}. Even with large initial stocks, the government is unable to achieve its objective under the assumed conditions.

Suppose tentatively that all market participants believe the government can achieve its objective, then market price as a function of pegged consumption is given by

$$(29) \quad Q^* = \frac{\alpha_0\beta_1 + \alpha_1\beta_0}{\alpha_1 + \beta_1} = \alpha_0 - \alpha_1 P_t + U_t,$$

and $E(P_t) = P^*$. With a competitive storage industry, $P^*_2 - T = P_1$. If P^*_2 is pegged at P^* by the government, then the demand for storage on the part of competitive arbitrageurs in the first period is perfectly elastic at the price $P^* - T$ (see D_{g3} in figure 7). This being the case, the government is not able to force price down to P_{10}. If it foolishly announces that it stands willing to sell its stocks at P_{10}, arbitrageurs will be in a frenzy to buy the entire stock at P_{10}, planning to sell it all back to the government at P^* in the very next period. In addition, even more of current production goes into storage than under competitive equilibrium. Far from increasing consumption to Q^* in the first period, the government program has the very opposite effect. This example suggests that quantity stabilization schemes may not be feasible in a free market economy.

Comparison with Previous Results

As noted, the previous literature on stabilization compares the welfare effects of zero storage with those of complete stabilization (usually of price). At the assumed levels of generality, it has not been possible to predict whether producers (buyers) gain or lose from stabilization. It has been shown in the present formulation, however, that relative to the case of competitive storage producers can expect to gain and buyers can expect to lose from complete or partial price stabilization on the part of the government. Economic efficiency is also reduced in that the expected losses exceed expected gains. The quantitative example suggests that the redistributive effects increase as demand and supply elasticities decline. For an initial period of abundance, the redistributive effects could be very substantial, amounting to several billion dollars. These results stand in sharp contrast to those reached by several writers, including Reutlinger and Hillman, Johnson, and Gray.

Concluding Observations

Under conditions assumed in this paper, competitive storage leads to the maximization of net benefits. However, competitive storage is consistent with wide price fluctuations and significant differences between expected and realized prices. External costs could, therefore, be quite significant and require further study and documentation. Risk aversion could give rise to insufficient storage and presumably greater price instability. Market participants might base their expectations on poor information relative to what may be available to, say, a government board. This possibility takes on added significance if structural parameters are changing. Finally, the distribution of benefits associated with competitive storage might be objectionable.

The possibility of market failure might provide a rationale for government intervention in the form of a stabilization program. Support for such programs has become commonplace in recent years; however, it has not been based on the evidence of market failure, which rigorous policy analysis requires as a prerequisite to policy prescription. We agree with Subotnik and Houck (1976), for example, that Cochrane and Danin, among others, appear to accept price stabilization as an ultimate policy goal requiring no further analysis of the linkages between the degree of price stability and welfare consequences. With this position, we take sharp exception. A carefully reasoned paper by Robinson supports the view that the case for a grain reserve program is not so pressing as to require immediate action without the benefit of further research.

An important objective of this paper has been to pave the way for more meaningful theoretical and empirical work on the efficiency and distributional consequences of grain storage. The theoretical analysis should be extended through allowing for changing stochastic demand and supply, risk aversion, and possible externalities. Precise estimates of demand and supply elasticities are required for many purposes, including the understanding of welfare effects of storage. Measurement of the joint probability density function for U_1 and V_1 would facilitate estimation of expected values for producer, buyer, and net efficiency benefits. Such information would represent an important advance over the exploratory findings given in this paper.

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The Distribution of Welfare Gains from International Price Stabilization under Distortions

Richard E. Just, Ernst Lutz, Andrew Schmitz, and Stephen Turnovsky

In a two-country model with distortions and general demand and supply functions, the welfare implications of international price stabilization are analyzed. The degree of nonlinearity of the excess demand function in the free trade exporting country as well as the distortions are found to be of crucial importance in determining who gains from stabilization. With a high degree of nonlinearity, producers in both countries as well as the exporting country as a whole lose from stabilization, whereas consumers in both countries and the importing country gain. This is contrary to previous results with linearity.

Key words: distortions, grain reserves, multiplicative disturbances, nonlinearity, price stabilization.

Some of the important distortions in international trade with agricultural commodities are tariffs, variable levies, quotas, and, for planned economies, state trading in general. With these policies, importing countries insulate their agricultural sectors from the unstable world market and achieve a high degree of price stability. By maintaining internal price stability, these countries, in effect, export their domestic instability to the exporting countries. Thus, while domestic stabilization may be attained as one of the benefits of these policies in the importing country, considerable repercussions may be realized in the form of instability in the exporting countries. The 1972–75 commodity boom, where internal Soviet and Common Market prices were artificially held nearly constant while U.S. export prices increased more than 200%, provides a good example (USDA 1974, 1976; International Wheat Council).

In view of the substantial instability that has developed in world grain markets during the 1970s, several proposals have been made for stabilizing world food prices (e.g., Hillman, Johnson, and Gray; Brookings Institution; Josling; Cochrane). All these proposals include some type of provision for setting up world buffer stocks to establish price stability. The question thus arises: who gains and who loses from stabilization? It appears that negotiations under the auspices of the World Wheat Council for implementing a world stabilization scheme are, at present, stalled partly because the issue of who gains and who loses is not clear. Would stabilization be a Pareto-superior move or would compensation be required? The purpose of this article is to analyze the distribution of the welfare gains from international price stabilization when prices are fixed by authorities in either the importing or the exporting country—the other country having a free market.

This article is an extension of the earlier work of Hueth and Schmitz, which considers stabilization in an international free trade framework, and of Bieri and Schmitz, which considers a similar issue where distortions are present. However, a major shortcoming of these papers is that linearity is used throughout. As pointed out in an important paper prepared for the World Food Conference, it is

> plausible that demand will become more elastic with the return of ample grain supplies, owing to the conversion of more grain to meat and the expansion of

Richard E. Just is an associate professor of agricultural and resource economics, Ernst Lutz is a postgraduate research agricultural economist, and Andrew Schmitz is a professor of agricultural and resource economics, University of California, Berkeley, and Stephen Turnovsky is a professor of economics, Australian National University, Canberra.

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consumption in poorer countries. A demand curve grown steeper at higher prices and shallower at lower prices enhances the consumer stake while diminishing the producer stake in reserves (Hillman, Johnson, and Gray, p. 8).

When considering the implications for stabilizing the prices of basic food items, it thus appears to be unrealistic to assume that demand is linear.

The introduction of nonlinearity in trade models has been exposited in an earlier paper by Just et al. However, that paper considers only free trade, whereas the present paper attempts to consider distortions that seem to be significant in international agricultural trade. Conclusions are similar to the earlier free trade results, and thus they appear to be fairly robust. The general conclusion is that producers in exporting countries prefer instability, but consumers in importing countries gain from stabilization. Exporting countries are generally worse off and importing countries are better off with stabilization, but with appropriate compensation, the world as a whole gains from stabilization.

The paper begins by conceptualizing the role of nonlinearity in determining gains from stabilization. The added complications of distortions in importing countries are also considered. Then a corresponding general mathematical framework is developed for examining the welfare impacts of stabilization on producers and consumers in both importing and exporting countries, depending on which of the four groups is responsible for the instability. The results are discussed first focusing on the exporting country, then on the importing country, and, finally, on the world as a whole. The extent to which the qualitative effects of stabilization can be reversed depending on nonlinearity is also considered.

Conceptualization

The intuition underlying the importance of the issues raised in this article is shown in figure 1, a standard diagrammatic two-country trade model with nonlinearity in demand and supply. For simplicity, consider only instability generated in the supply sector of the exporting country. Suppose supplies S'_1 and S''_1 each occur with probability 0.5 in the exporting country.[1] As shown in figure 1, D_1, S_2, and D_2

[1] Figure 1 is drawn so that S'_1 and S''_1 (and S_1) have a common origin to be consistent with the mathematical model presented later in the paper. The justification for and implications of assuming multiplicative rather than additive disturbances have been discussed by Turnovsky. It may also be noted that supply curves are drawn with some positive degree of elasticity not necessarily indicating that prices are forecast without error but merely that producer response is possible after the stabilization program is implemented.

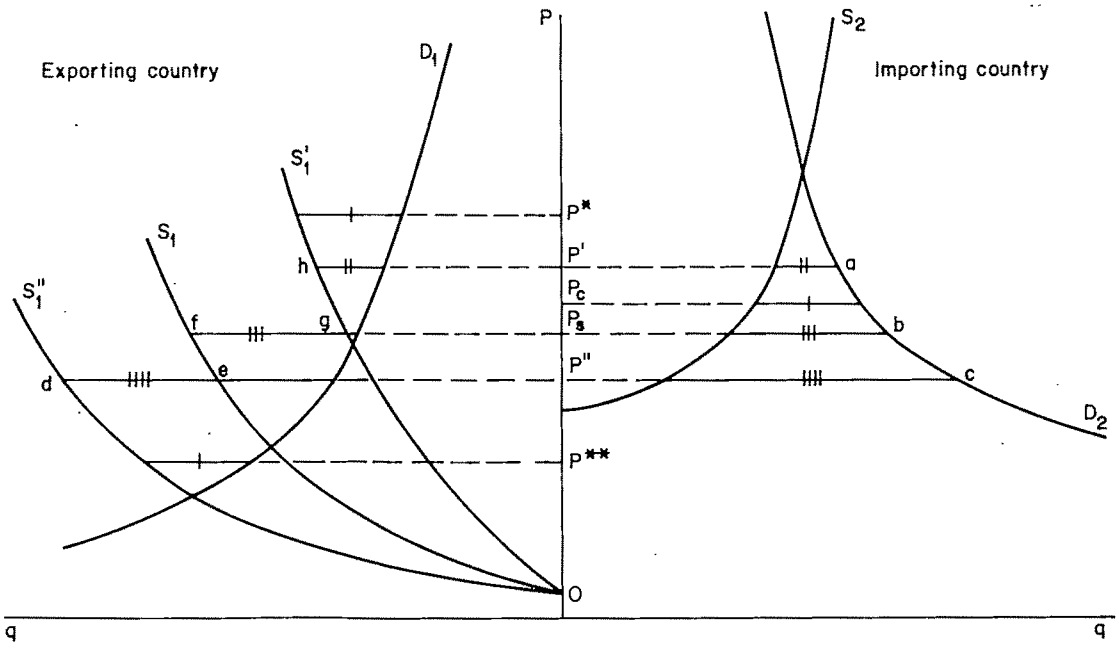


Figure 1. International price stabilization with nonlinear demand and supply functions

represent demand in the exporting country and supply and demand in the importing country, respectively. Under free trade, price P' results with supply S'_1 and price P'' results with supply S''_1. If supply in the exporting country is stabilized at S_1, however, the resulting stabilized price is P_S.[2]

Using standard surplus analysis, Hueth and Schmitz have previously shown that under linearity stabilization leads to gains for producers in the exporting country but losses for consumers in the exporting country and for both producers and consumers in the importing country.[3] However, these results can be reversed under nonlinearity for certain groups. For example, with stabilization at price P_s, consumers in the importing country gain the surplus area $P'abP_s$ when S'_1 occurs and lose the area P_sbcP'' when S''_1 occurs. With the curvature in figure 1, the area $P'abP_s$ is by visual inspection larger than P_sbcP'', and, hence, expected gains from stabilization are positive, not negative as in the Hueth and Schmitz case.

Considering the producers in the exporting country, a reversal can be obtained in this case since, in figure 1, producers lose the difference in Ode and P_sfeP'' when S''_1 occurs and the difference in $P'hgP_s$ and Ofg when S''_2 occurs. By visual inspection, the sum of these losses is positive; gains are not made as in the Hueth and Schmitz case.

Consider further the case where distortions are introduced by price fixing in importing countries. Suppose for simplicity that price P_c is imposed for both production and consumption in figure 1. In this case, excess demand is fixed and, hence, price P^* results in the exporting country when supply is S'_1; P^{**} results when supply S''_1 occurs. This demonstrates how price fixing in the importing country can export price instability to the exporting country. In the absence of stabilization policies in the exporting country, prices vary between P^* and P^{**} (with price fixing in the importing country) rather than between P' and P'' (as in the absence of price fixing in the importing country). Thus, instability in the exporting country can be increased.[4]

When price fixing is introduced, it is also clear that the welfare impacts on the various groups are changed, and the gains or losses from stabilization are modified. A diagrammatic analysis of these gains or losses becomes much more difficult with such price fixing. Thus, a mathematical analysis is pursued in the remainder of this paper.

The Model

The mathematical model used in this paper is an extension of the two-country, free trade model developed by Just et al. As in the earlier paper, the methodology is based on Turnovsky's nonlinear generalization of the Massell framework.[5]

Consider two countries, 1 and 2, having demand and supply functions

$$(1) \qquad d_i = u_i D_i(P) \text{ for } D'_i < 0 \ (i = 1, 2)$$

and

$$s_i = v_i S_i(P) \text{ for } S'_i > 0 \ (i = 1, 2),$$

where d_i is demand in country i, s_i is supply in country i, and P is price. The terms u_i and v_i denote stochastic disturbances with means $\bar{u}_i$ and $\bar{v}_i$, respectively, each having finite second moments. The producer and consumer prices in country 2 (taken to be the importing country) are assumed to be fixed by governmental policies at P^P and P^C, respectively.

Excess demand in country 1, the exporting country, is defined by

$$(2) \qquad X_1(P, u_1, v_1) = u_1 D_1(P) - v_1 S_1(P),$$

where

$$(3) \qquad \partial X_1(P, u_1, v_1)/\partial P \equiv X_{1P} = u_1 D'_1(P) - v_1 S'_1(P) < 0.$$

[2] Note that this stabilization could be accomplished by a costless storage activity, increased information availability, quotas, or other forms of government programs. If S_1 is attained by buffer stocks, then the horizontal difference between S_1 and S'_1 (S''_1) at price P_s represents the amount released (acquired) by the buffer stock authority. The area above S_1 and below P_s measures expected producer surplus in this case because it is the expectation of the areas above S'_1 and S''_1 and below price when S_1 represents the (horizontal) expectation of S'_1 and S''_1.

[3] Although the standard surplus analysis has several important shortcomings (see Currie, Murphy, and Schmitz for a useful survey), better tools are extremely difficult to apply in the detailed problem of this paper. For this reason, surplus analysis has come to be a rather standard approach in analyzing price stabilization. Hence, this approach is also used here, but the limitations should be kept firmly in mind.

[4] The reader may verify, however, that whether or not price instability is increased in the exporting country depends on where P_c is set (or, equivalently, on trade volume).

[5] However, Turnovsky (as well as the present paper) uses multiplicative rather than additive disturbances. A rather lengthy justification for doing so can be found in Turnovsky. Also, the larger the quantities involved, i.e., the larger the distance between the demand and supply functions and the price axis, the less important is the difference between additive and multiplicative disturbances.

For expositional ease, the excess demand function is assumed convex (or linear), so that

$$(4)\quad \partial^2 X_1(P, u_1, v_1)/\partial P^2 = X_{1PP} = u_1 D''_1(P) - v_1 S''_1(P) \geq 0.$$

While the assumption of convexity seems reasonably plausible, it is made largely for convenience. The subsequent results can be easily reinterpreted in the case of a concave excess demand function.

Excess demand in country 2 is defined by[6]

$$(5)\quad X_2(u_2, v_2) = u_2 D_2(P^C) - v_2 S_2(P^P).$$

Since country 1 is the exporting country and country 2 is the importing country,[7]

$$(6)\quad X_1 < 0 \text{ and } X_2 > 0.$$

Aggregate excess demand is then defined by

$$(7)\quad X(P, u, v) = X_1(P, u_1, v_1) + X_2(u_2, v_2),$$

where $u = (u_1, u_2)$, $v = (v_1, v_2)$, and

$$(8)\quad X_P = X_{1P} < 0 \text{ and } X_{PP} = X_{1PP} \geq 0.$$

It will be seen that $X(P, u, v)$ is linear in the random variables u and v. In the absence of price stabilization, the short-run market price P is determined, where

$$(9)\quad X(P, u, v) = X_1(P, u_1, v_1) + X_2(u_2, v_2) = 0,$$

the solution of which can be written in the form

$$(10)\quad P = \phi(u, v).$$

Suppose that an international stabilization authority establishes a buffer stock and is willing to buy or sell the commodity at a price P_s such that, at that price, the buffer stock is self-liquidating; that is, at the stabilized price P_s, the authorities expect the random fluctuations in u and v to even out so that, on the average, they neither accumulate nor deplete stocks of the commodity. Thus, P_s is the solution to the equation

$$(11)\quad X(P_s, \bar{u}, \bar{v}) = 0,$$

from which it follows that

$$(12)\quad P_s = \phi(\bar{u}, \bar{v}).$$

Following Turnovsky and Just et al., the welfare gains to producers are evaluated in terms of their effects on expected producers' surplus. Likewise, the welfare gains to consumers are measured in terms of their effects on expected consumers' surplus. Since numerous cases could be considered, the method is illustrated with only a single case; results are then presented for all cases.

Consider the gains from stabilization to producers in country 1 in a situation where the only random disturbance is in v_2, that is, where supply disturbances exist only in country 2. All other variables remain fixed at their respective means, $\bar{u}_1$, $\bar{v}_1$, and $\bar{u}_2$. The gains from stabilization to producers in country 1 are given by

$$(13)\quad G_1^P = \int_{P(\bar{u}_1, \bar{v}_1, \bar{u}_2, \bar{v}_2)}^{P_s(\bar{u}_1, \bar{v}_1, \bar{u}_2, \bar{v}_2)} \bar{v}_1 S_1(P')\mathrm{d}P'.$$

From Jensen's inequality, expected gains are

$$(14)\quad E(G_1^P) \gtrless 0 \text{ according as } \partial^2 G_1^P/\partial v_2^2 \gtrless 0.$$

Differentiating equation (13) twice with respect to v_2 yields

$$(15)\quad \partial^2 G_1^P/\partial v_2^2 = -v_1 S'_1(\partial P/\partial v_2)^2 - v_1 S_1\, \partial^2 P/\partial v_2^2.$$

Differentiating the equilibrium condition (9) with respect to v_2,

$$(16)\quad \partial P/\partial v_2 = S_2(P^P)/X_{1P} < 0,$$

and

$$\partial^2 P/\partial v_2^2 = -S_2^2(P^P)\, X_{1PP}/X_{1P}^3 > 0.$$

Inserting equation (16) into equation (15) yields the direction of the gains from stabilization for producers in country 1 when supply fluctuations in country 2 are stabilized:

$$(17)\quad \frac{\partial^2 G_1^P}{\partial v_2^2} = \frac{S_2^2(P^P)}{X_{1P}^2}\left[-v_1 S'_1 + v_1 S_1 \frac{X_{1PP}}{X_{1P}}\right] < 0.$$

Thus, producers in country 1 (the exporting country) always lose from stabilization of country 2's supply disturbances when country 2 (the importing country) has fixed prices. Conversely, this would imply that U.S. wheat producers are likely to benefit from destabilized production in importing countries that have controlled prices.

[6] In reality, excess demand may be somewhat responsive to prices even in such countries as Japan and those in the Common Market. However, this model is intended to provide a tractable and thus useful abstraction. In the more general case, the results would presumably be closer to those in Just et al. (which are also more ambiguous).

[7] If the indices are reversed, the model addresses the question of who gains from stabilization in a situation where the exporting country fixes prices and dumps any excess onto a free market in importing countries. This situation might apply for perishable products and for exporting countries that have no storage facilities.

Results

Calculations like those above can be performed to evaluate the welfare gains for each producer or consumer group or country from stabilization of any of the four disturbances in the model. Following this approach, table 1 has been developed to show the direction of impacts on the exporting country when price controls are imposed by the importing country. Table 2 shows the direction of impacts on various groups in the importing country where price controls are in effect.

Comparing these with the Just et al. results under free trade, in their case the aggregate excess demand function is important as far as the nonlinearity of the demand and supply functions is concerned. Under price fixing and restricted trade, however, the excess demand function of the country with a free market is the determining factor. The properties (other than location) of the demand and supply functions in the importing country where price is controlled are of no consequence.

Gains of the Exporting Country

Evidently, if disturbances originate in either the demand or the supply sector of the importing country, producers in the exporting country lose from stabilization. This is in contrast to the earlier results obtained by Just et al., where a loss is only certain for supply disturbances but where the results for demand disturbances are ambiguous.

The results for stabilization of disturbances in the exporting country are ambiguous. However, with increasingly inelastic supply, producers tend to lose from stabilization. Thus, because of price fixing by importing countries, producers in the exporting country prefer instability more strongly than under free trade.

The welfare gains for consumers from price stabilization are ambiguous in all cases. However, consumers tend to gain with an increasing level of domestic demand, an increasing elasticity of demand, and an increasing slope of domestic supply.

The exporting country as a whole unambiguously loses from stabilization if the disturbances originate in the importing country. By comparison with Just et al., a similar result is not obtained for the stabilization of demand disturbances when prices are not controlled in the importing country. In the same situation the effects on country 1 are ambiguous and depend on relative elasticities and curvatures. If domestic supply variations are stabilized,

Table 1. Welfare Gains from Stabilization of Country 1 under Price Fixing in Country 2

Impact Group	Demand Fluctuations in Country 1 (u_1)	Demand Fluctuations in Country 2 (u_2)
Country 1		
Producers	$\frac{D_1^2}{X_{1P}^2}\left[-v_1S'_1 - 2v_1S_1\frac{D'_1}{D_1} + v_1S_1\frac{X_{1PP}}{X_{1P}}\right]$	$\frac{D_2^2}{X_{1P}^2}\left[-v_1S'_1 + v_1S_1\frac{X_{1PP}}{X_{1P}}\right] < 0$
Consumers	$\frac{D_1^2}{X_{1P}^2}\left[3u_1D'_1 - 2X_{1P} - u_1D_1\frac{X_{1PP}}{X_{1P}}\right]$	$\frac{D_2^2}{X_{1P}^2}\left[u_1D'_1 - u_1D_1\frac{X_{1PP}}{X_{1P}}\right]$
Country	$\frac{D_1^2}{X_{1P}^2}\left[X_1\left(2\frac{D'_1}{D_1} - \frac{X_{1PP}}{X_{1P}}\right) - X_{1P}\right]$	$\frac{D_2^2}{X_{1P}^2}\left[X_{1P} - X_1\frac{X_{1PP}}{X_{1P}}\right] < 0$ if $X_1 < 0$
World	$-\frac{D_1^2}{X_{1P}} > 0$	$-\frac{D_2^2}{X_{1P}} > 0$
	Supply Fluctuations in Country 1 (v_1)	Supply Fluctuations in Country 2 (v_2)
Country 1		
Producers	$\frac{S_1^2}{X_{1P}^2}\left[-2X_{1P} - 3v_1S'_1 + v_1S_1\frac{X_{1PP}}{X_{1P}}\right]$	$\frac{S_2^2}{X_{1P}^2}\left[-v_1S'_1 + v_1S_1\frac{X_{1PP}}{X_{1P}}\right] < 0$
Consumers	$\frac{S_1^2}{X_{1P}^2}\left[u_1D'_1 + 2u_1D_1\frac{S'_1}{S_1} - u_1D_1\frac{X_{1PP}}{X_{1P}}\right]$	$\frac{S_2^2}{X_{1P}^2}\left[u_1D'_1 - u_1D_1\frac{X_{1PP}}{X_{1P}}\right]$
Country	$\frac{S_1^2}{X_{1P}^2}\left[X_1\left(2\frac{S'_1}{S_1} - \frac{X_{1PP}}{X_{1P}}\right) - X_{1P}\right] > 0$ if $X_1 > 0$	$\frac{S_2^2}{X_{1P}^2}\left[X_{1P} - X_1\frac{X_{1PP}}{X_{1P}}\right] < 0$ if $X_1 < 0$
World	$-\frac{S_1^2}{X_{1P}} > 0$	$-\frac{S_2^2}{X_{1P}} > 0$

Table 2. Welfare Gains from Stabilization of Country 2 under Price Fixing in Country 2

Impact Group	Demand Fluctuations in Country 1 (u_1)	Demand Fluctuations in Country 2 (u_2)
Country 2		
Producers	$\frac{D_1^2}{X_{1P}^2} v_2 S_2 \left[-2\frac{D'_1}{D_1} + \frac{X_{1PP}}{X_{1P}} \right]$	$\frac{D_2^2}{X_{1P}^2} \left[v_2 S_2 \frac{X_{1PP}}{X_{1P}} \right] < 0$
Consumers	$\frac{D_1^2}{X_{1P}^2} u_2 D_2 \left[2\frac{D'_1}{D_1} - \frac{X_{1PP}}{X_{1P}} \right]$	$\frac{D_2^2}{X_{1P}^2} \left[-2X_{1P} - u_2 D_2 \frac{X_{1PP}}{X_{1P}} \right] > 0$
Country	$\frac{D_1^2}{X_{1P}^2} X_2 \left[2\frac{D'_1}{D_1} - \frac{X_{1PP}}{X_{1P}} \right]$	$\frac{D_2^2}{X_{1P}^2} \left[-2X_{1P} - X_2 \frac{X_{1PP}}{X_{1P}} \right] > 0$ if $X_2 > 0$
World	$-\frac{D_1^2}{X_{1P}} > 0$	$-\frac{D_2^2}{X_{1P}} > 0$
	Supply Fluctuations in Country 1 (v_1)	Supply Fluctuations in Country 2 (v_2)
Country 2		
Producers	$\frac{S_1^2}{X_{1P}^2} v_2 S_2 \left[-2\frac{S'_1}{S_1} + \frac{X_{1PP}}{X_{1P}} \right] < 0$	$\frac{S_2^2}{X_{1P}^2} \left[-2X_{1P} + v_2 S_2 \frac{X_{1PP}}{X_{1P}} \right]$
Consumers	$\frac{S_1^2}{X_{1P}^2} u_2 D_2 \left[2\frac{S'_1}{S_1} - \frac{X_{1PP}}{X_{1P}} \right] > 0$	$\frac{S_2^2}{X_{1P}^2} \left[-u_2 D_2 \frac{X_{1PP}}{X_{1P}} \right] > 0$
Country	$\frac{S_1^2}{X_{1P}^2} X_2 \left[2\frac{S'_1}{S_1} - \frac{X_{1PP}}{X_{1P}} \right] > 0$ if $X_2 > 0$ < 0 if $X_2 < 0$	$\frac{S_2^2}{X_{1P}^2} \left[-2X_{1P} - X_2 \frac{X_{1PP}}{X_{1P}} \right] > 0$ if $X_2 > 0$
World	$-\frac{S_1^2}{X_{1P}} > 0$	$-\frac{S_2^2}{X_{1P}} > 0$

the country loses from stabilization with increasing levels of exports and with a decreasing elasticity of supply. If domestic demand disturbances are stabilized, the country loses with increasing elasticity of demand.

Gains for the Importing Country

Producers lose from stabilization if the disturbances originate in the demand sector of the importing country or the supply sector of the exporting country. The stabilization of demand fluctuations in the exporting country produces an ambiguous result, but producers in the importing country tend to lose with increasing elasticity of demand in the exporting country. If domestic supply is stabilized, producers tend to lose with an increasing level of supply.

The distribution of the welfare gains between producers and consumers in the importing country is arbitrary in this case, since prices for both groups are fixed and since the government, which does the trading or strongly regulates trade, could also take care of the distribution of surpluses or deficits.

The stabilization of supply and demand fluctuations in the importing country and supply fluctuations in the exporting country results in welfare gains for consumers in the importing country. If demand fluctuations in the exporting country are stabilized, consumers in the importing country tend to gain with an increasing elasticity of demand in the exporting country.

The importing country gains from the stabilization of domestic supply and demand and also foreign supply disturbances. It also tends to gain from the stabilization of demand disturbances in the exporting country with an increasing elasticity of demand.

Gains of the World

In all cases the gains from stabilization for the world as a whole are positive. Thus, there are economic incentives for cooperation, since all countries and all groups within countries could be made better off with stabilization with appropriate compensation. However, since other diverse economic and political objectives are involved, the negotiations of an international stabilization scheme are complex and encounter major obstacles.

Importance of the Degree of Nonlinearity

To investigate the role of nonlinearity, note that X_{1PP} is the second derivative of the excess demand curve in the free market country; X_{1P} is the first derivative. The ratio $|X_{1PP}/X_{1P}|$ might be considered a measure of the local nonlinearity in the excess demand for country 1.[8] A similar concept might be defined for country 2. However, the degree of nonlinearity in country 2—the country with price fixing—plays no role in determining the effects of stabilization in tables 1 and 2.

Noting that $X_{1PP}/X_{1P} \leq 0$ by assumption, the effect of the degree of nonlinearity can be investigated by considering a change in the (negative) magnitude of X_{1PP}/X_{1P}. For example, consider gains for country 1 producers when demand is fluctuating in country 1. Since $(D_1^2/X_{1P}^2)v_1S_1 > 0$, a sufficiently large degree of nonlinearity (X_{1PP}/X_{1P} sufficiently small) would cause country 1 producers to lose from stabilization of u_1. Similarly, the situation of extreme nonlinearity can be examined in each of the other cases considered in tables 1 and 2 to get an idea of the effect of nonlinearity. The results of doing so are presented in table 3 along with the implied results for the case of linearity (where $X_{1PP}/X_{1P} = 0$).[9]

Reversals of impacts take place in several cases as the degree of nonlinearity is altered; whereas, in other cases, the incidence of reversal depends on the supply or demand elasticity (slope). As nonlinearity increases,[10] the country 1 effect from stabilizing internal demand (u_1) switches from positive to negative. Similarly, country 2 gains switch from negative to positive as do gains for consumers in country 2. In both the cases of stabilizing dis-

[8] The ratio is similar in definition to the Arrow-Pratt measure of local or absolute risk aversion. The properties of a function, defined by the second derivative divided by the first, are discussed extensively by Pratt.

[9] $X_{1PP}/X_{1P} = 0$ implies linearity of the excess demands. Excess demand would necessarily be linear if supply and demand are linear. However, certain situations of nonlinear supply and demand could also lead to a linear excess demand.

[10] An increase in nonlinearity implies an increase in nonlinearity of the excess demand curve for the free market country. This could result from an increase in nonlinearity in either its supply or demand.

Table 3. International Price Stabilization: Who Gains and Who Loses in Polar Cases of Nonlinearity

Impact Group	Demand Fluctuations in Country 1 (u_1)		Demand Fluctuations in Country 2 (u_2)	
	Extreme Nonlinearity[a]	Linearity[a]	Extreme Nonlinearity[a]	Linearity[a]
Country 1				
Producers	−	?	−	−
Consumers	+	?	+	−
Country	−	+	−	−
Country 2				
Producers	−	+	−	0
Consumers	+	−	+	+
Country	+	−	+	+
World	+	+	+	+

	Supply Fluctuations in Country 1 (v_1)		Supply Fluctuations in Country 2 (v_2)	
	Extreme Nonlinearity	Linearity	Extreme Nonlinearity	Linearity
Country 1				
Producers	−	?	−	−
Consumers	+	?	+	−
Country	−	?	−	−
Country 2				
Producers	−	−	−	+
Consumers	+	+	+	0
Country	+	+	+	+
World	+	+	+	+

[a] + indicates a gain; − indicates a loss; 0 indicates no impact; and ? indicates uncertain.

turbances in country 1, the impacts on producers and consumers in country 1 may or may not switch depending on elasticities of the respective supply and demand functions. In the cases of stabilizing disturbances in country 2, few reversals occur as the degree of nonlinearity is altered. With extreme nonlinearity, all groups are affected the same (qualitatively) regardless of which disturbance is stabilized. With stabilization, producers in both countries lose, consumers in both countries gain, the exporting country loses, the importing country gains, and the world as a whole gains (assuming appropriate compensation is made).

Nonlinearity need not be unrealistically excessive to reach a reversal (from the case of linearity), at least in some cases. For example, consider the impact on the exporting country (country 1) of stabilizing demand fluctuations in the exporting country. Suppose the exporting country's supply and demand follow the popular log-linear formulation with

$$D_1 = AP^{-\delta} \text{ for } 0 < \delta < 1, \tag{18}$$

$$S_1 = BP^{\gamma} \text{ for } 0 < \gamma < 1, \tag{19}$$

and

$$X_1 = AP^{-\delta} - BP^{\gamma}. \tag{20}$$

From table 1, it is evident that a reversal is obtained if

$$2D'_1/D_1 - X_{1PP}/X_{1P} > X_{1P}/X_1, \tag{21}$$

since $D_1^2/X_{1P}^2 > 0$ and $X_1 < 0$. Inserting equations (18), (19), and (20) and noting that $D'_1 = -\delta D_1/P$, $X_{1P} = (-\delta D_1 + \gamma S_1)/P$, and $X_{1PP} = [\delta(\delta + 1)D_1 + \gamma(\gamma - 1)S_1]/P^2$, equation (21) becomes

$$-2\frac{\delta}{P} - \frac{\delta(\delta + 1)D_1 + \gamma(\gamma - 1)S_1}{P(-\delta D_1 + \gamma S_1)} > \frac{-\delta D_1 + \gamma S_1}{P(D_1 - S_1)}.$$

Finding a common denominator on the left-hand side and cross multiplying, one finds that equation (21) is satisfied if

$$S_1^2[2\gamma(\delta - \gamma) + \gamma] + S_1D_1[\gamma(\gamma - 1)\delta(\delta + 1)] \gtrless 0, \tag{22}$$

according as $\gamma S_1 - \delta D_1 \gtrless 0$. Thus, a sufficient condition for equation (21) is that

$$\gamma S_1 - \delta D_1 > 0, \tag{23}$$

$$2\gamma(\delta - \gamma) - \gamma < 0, \tag{24}$$

and

$$\gamma(\gamma - 1) - \delta(\delta + 1) < 0. \tag{25}$$

This is a reasonable possibility, since equations (24) and (25) obviously hold if $\gamma > \delta$ and $0 < \gamma, \delta < 1$. Also, $X_1 < 0$ implies $D_1 - S_1 < 0$; hence, $\gamma > \delta$ implies $SD_1 - \gamma S_1 < 0$ or that equation (23) holds. In summary, the Hueth and Schmitz result under linearity is reversed under log-linearity if the supply price elasticity is greater than the (absolute value of the) demand price elasticity in the exporting country (for the case where exporting country demand disturbances are stabilized). Hence, this case of reversal seems quite possible given, e.g., the empirical study by Sarris, who estimated for Canada supply elasticities of 0.86 and demand elasticities of −0.13 under the assumption of log-linearity.

These results emphasize the importance of econometric work focusing on the degree of nonlinearity in determining exactly who gains and who loses from stabilization and by how much. Even the qualitative effects from stabilization can be reversed as the degree of nonlinearity changes. The results suggest that, before the validity of many simulation studies on the effects of stabilization can be established, considerable econometric investigation is required to verify functional forms. This unfortunately has not been the case in the large number of such studies that have been recently forthcoming.[11]

However, these results emphasize the importance of econometric work only on free market countries, since information on the degree of nonlinearity is important in determining an appropriate policy only for those countries. Econometric work in determining the degree of nonlinearity in controlled economies is not of the same importance for stabilization policy purposes. This is a comforting result since econometric work in controlled economies is very difficult if not impossible because of multicollinearity and identification problems.

[11] A specific citation of these studies is avoided because a comprehensive list would be required for fairness (see Sarris for a partial enumeration of these attempts). Although a few such studies have examined cases of both linear and log-linear equations, this is also insufficient. For example, with a log-linear function $Z_1 = AP^{\alpha}$, one finds $Z_{1PP}/Z_{1P} = (\alpha - 1)/P$. Thus, there is little flexibility with respect to nonlinearity. The degree of nonlinearity is completely determined by the elasticity (for a given price).

Conclusions

Under free trade, with convexity of the aggregate excess demand function (Just et al.), the importing country as a whole and consumers in both exporting and importing countries tend to gain from price stabilization, whereas exporting countries and producers in these countries tend to lose, although this result was not obtained in every case. Under the price-fixing policies in the importing countries considered in this article, these conclusions are even more strongly supported.

With strong nonlinearity, producers and exporting countries (as a whole) lose, while consumers and importing countries gain from stabilization in every case. The conclusions thus support the assertion by Hillman, Johnson, and Gray that

> A demand curve grown steeper at higher prices and shallower at lower prices enhances the consumer stake while diminishing the producer stake in reserves. This calls for a dramatic reversal from policies which accumulate reserves ostensibly in the producer's interests, away from the notion that stocks acquisitions benefit producers, toward explicit recognition of the overriding consumer interest (p. 8).

However, if nonlinearity is not sufficiently strong, then the conclusions of Hillman, Johnson, and Gray may not apply. For example, under insufficient nonlinearity, country 2 producers benefit and country 2 consumers lose; and the exporting country gains and the importing country loses from stabilizing country 1 demand disturbances (u_1).

To gain more insight into the situation in the world food stock issue, one can consider the associated economic conditions. The major component of instability is generated by fluctuating supply either in importing or exporting countries. Also, agricultural supply is rather inelastic. Hence, the more relevant results where world food stocks are concerned are contained in the last part of table 3. If supply is sufficiently inelastic in these cases, the three quantities that result in uncertain impacts (last half of table 3) approach zero. Hence, the general conclusion that can be reached regardless of nonlinearity and the source of supply disturbances is that producers in the exporting country and the exporting country as a whole either lose or are unaffected and that consumers in the importing country and the importing country as a whole gain or are unaffected by stabilization. The results thus tend to explain why major exporters such as the United States are reluctant to participate in a world wheat reserves program. Judging solely on the basis of economic efficiency criteria, it seems that some type of compensation may be needed to induce major exporters to comply with an internationally coordinated reserve system or that importers should operate their own reserves. In the case of other groups and in determining the quantitative effects, however, only sufficient econometric investigation into the degree of nonlinearity can lead to valid and useful answers.

The approach used in this article does not capture all of the economic gains (or losses) that are likely to result from stabilization. It has been argued by Just and shown in rigorously developed theorems and propositions by Batra and Feder, Just, and Schmitz, for example, that a reduction in instability would result in a more efficient allocation of resources and, hence, in a higher income. Clearly, through price fixing the importing countries can capture those gains. But because of price fixing, the importing countries may be exporting their price instability to the free markets of the exporting countries, increasing the uncertainty in their economy and causing a loss in efficiency and income.[12] The size of this loss for exporting countries has not been investigated here.

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[12] One can easily show that this would be the case in a two-country Massell framework. Suppose demands in country 1 (the exporting country) and country 2 (the importing country) are given by $p = a_i - b_i q + \delta_i$ for $i = 1, 2$, and supplies are given by $p = \alpha_i + \beta_i q + \epsilon_i$, where p is price; q is quantity; a_i, b_i, α_i, and β_i are parameters; and δ_i and ϵ_i are random disturbances. It can be shown that

$$\frac{\bar{\sigma}_p}{\sigma_p} = \frac{[b_1\beta_2(b_1 + \beta_1) + b_1\beta_1(b_2 + \beta_2)]^2}{b_2^2\beta_2^2(b_1 + \beta_1)^2} > 1,$$

where σ_p is the variance of price under free trade conditions and $\bar{\sigma}_p$ is the variance with price fixing in the importing country. Thus, it is evident that price fixing in the importing country actually causes a transfer of instability from the importing country to the exporting country.

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A Welfare Analysis of Long-Term Forest Products Price Stabilization

Darius M. Adams, Richard W. Haynes, and David R. Darr

The prospective welfare and market impacts of federal efforts to stabilize prices of wood products are examined for two alternative strategies involving manipulating Forest Service harvest levels. Generally, these stabilization strategies yield substantial net benefits. Consumers consistently gain, while losses by stumpage producers and by end product suppliers in the South are largely offset by gains in the West.

Key words: forest policy, price stabilization, welfare gains.

The management of federal forest lands has traditionally been governed by policies oriented toward maintaining stable timber harvest levels without regard to the influence these levels have on prices and consumption of wood products. In the wake of the volatile lumber and plywood price movements of the past decade, however, there is growing interest in the potential role of public harvests in damping cyclical price fluctuations. Continued large-scale substitution of other materials for wood products has also led to pressures on federal agencies to expand harvests to retard the long-term rise in relative prices of stumpage and products. These pressures flow from the relative adverse impacts of substitutes compared with wood products. Consideration of price and market effects in the establishment of federal timber harvest policy could markedly alter harvest levels on national forest lands. Changing harvest levels, in turn, have the potential to affect the economic welfare of a broad spectrum of producers and consumers of timber and wood products.

The purpose of this article is to examine the prospective market and welfare impacts of federal efforts to stabilize prices of wood products. This examination is restricted to stabilization strategies involving only the manipulation of national forest timber supply. Perspective on the economic and policy issues involved is provided in the first two sections, which review the current role of national forests in timber markets and previous proposals for federal price stabilization programs in forestry. The third section outlines the econometric model used to simulate wood products markets under price stabilization programs. The treatment is brief, however, since the central concern here is with the market and welfare outcomes of alternative strategies. In the final sections, two specific supply-based price stabilization strategies are examined in terms of their impacts on the net economic welfare of consumers and producers, the real wealth of timber producers, payments to variable factors of production, and revenues received by public timber management agencies.

Darius M. Adams is an associate professor of forest economics, Oregon State University, Richard W. Haynes is an economist and David R. Darr is a principal economist with the Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Portland, Oregon.
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The Current Role of National Forests in Timber Markets

Since the turn of the century, the federal government has been the largest single owner of standing timber. It assumed this role at the instigation of early conservationists who advocated the development of renewable resources by the public sector for the benefit of the people as a whole (Ise). Presently, federal agencies control 21% (107 million acres) of commercial timberland in the United States (USDA Forest Service 1973). The bulk of these holdings (97 million acres) is managed by the U.S. Forest Service and contains 51% of the domestic softwood sawtimber inventory (volume of standing timber). The Forest Service sells standing timber, or stumpage, from the national forests through public auction. In 1970, more than 2 billion cubic feet of soft-

wood timber (22% of the total harvest) was harvested from the national forests.

The bulk of national forest timber (96%) lies in the Rocky Mountain and western coastal states. Because of the uneven geographical distribution of national forest lands, the influence of Forest Service harvests on wood products markets and the wood-using industry is not uniform across regions. In many areas of the West, the Forest Service is the dominant supplier of timber and has the potential to exert a strong influence on the prices of stumpage. This influence extends to the East inasmuch as shifts in western stumpage prices affect the prices of lumber and other end products in national markets.

Recent congressional legislation directs the Forest Service to manage the national forests for multiple uses in an effort to provide a broad range of goods and services in nondiminishing quantities over time.[1] Beyond this broad mandate, however, there has never been an explicit determination, nor is there any public consensus, regarding what role national forests should play in supplying the nation's wood demands. In determining harvest levels on national forest lands, the Forest Service has generally attempted to maintain a neutral posture in dealing with issues that affect either prices or the structure of the wood products industry. Although at times it has supported the argument that lower wood prices lead to lower housing costs (which would benefit a broad segment of the public), the Forest Service has never increased its harvest levels with this specific objective in mind. Similarly, in the administration of timber sales, the Forest Service has pursued its objective of securing a fair return while neither penalizing the efficient firms nor subsidizing the inefficient firms that purchase public timber.[2]

National forests in the West typically contain a high proportion of old growth timber. Inventories per acre of land for this old growth timber are higher than would be maintained in future timber stands. The reason for the number of proposals on how to schedule the harvest on national forest lands is that the old growth timber can be liquidated at various rates over time. Alternative proposals for scheduling the harvest vary in terms of the criteria used for measuring the impacts of the flow of timber from national forests. There is less debate over the scheduling method to be used to determine timber flow after the old growth has been liquidated. Growth potential after harvest of the old growth is generally referred to as the long-run sustained yield potential.

Currently, harvest levels on the national forests are established so as to produce a "nondeclining even flow" of timber over the planning period.[3] Plans are usually developed for a minimum of thirty decades and, in some cases, longer. Under the even flow policy, output is a function of the current volume and condition of the timber inventory and anticipated growth. Given these physical attributes, a fixed level of cut is calculated that can be sustained without variance to the planning horizon. Prices and potential future market demands for stumpage and wood products are not considered.

Previous Proposals

The potential impacts of national forest harvest on prices of stumpage and wood products have been recognized for many years. In the early twenties, Mason and other foresters foresaw the opportunity to relieve the perennial problem of weak and unstable lumber prices by constraining lumber supplies from public lands. Mason urgued the Forest Service and private landowners to adopt a policy of "sustained yield" in setting harvest levels. During the Depression, there was also some evidence that the Forest Service voluntarily restricted harvests to stem the decline in wood prices. In the period of rapid economic expansion following World War II, lumber prices rose steadily, prompting Gulick and others to suggest that national forest harvests might be expanded during periods of rising demand to stabilize prices. Gulick's proposal has been repeated on numerous occasions (Zivnuska, Newport) in the past decade as prices in the forestry sector have climbed sharply under unprecedented levels of housing activity.

[1] This legislation comprises the Multiple Use Sustained Yield Act of 1960, the Renewable Resources Planning Act of 1974, and the National Forest Management Act of 1976.

[2] The Forest Service has placed restrictions on the exportation of logs cut from national forest lands and has developed a program designed to set aside timber for small operators in response to congressional legislation.

[3] The National Forest Management Act of 1976 has defined the criteria for establishing harvest flows as a "quantity equal to or less than a quantity which can be removed from a forest annually in perpetuity on a sustained yield basis" (U.S. Code, p. 1610). Current Forest Service criteria are under review for compliance with the Act.

The first detailed examination of a price stabilization program was presented by Vaux in his analysis of public timber supply alternatives in the Douglas Fir region of western Oregon and Washington. Vaux concludes that the national forests of that region have sufficient inventory volumes of timber to support a program of regional stumpage price stabilization to the year 2000, with little impact on long-term sustainable harvest potential. More recently, the Forest Service (USDA Forest Service 1976) has examined a somewhat more comprehensive national program to stabilize real prices of end products. Like the Vaux study, however, the analysis focuses almost exclusively on the physical availability of timber for an agency to conduct a program of price stabilization. To date, no proposal has been examined in terms of the prospective welfare impacts of price stabilization on consumers and producers nor has consideration been given to potential interregional effects of large shifts in public harvest.

Whether a price stabilization strategy uses stumpage or end product prices as a proximate criterion is, in part, an artificial distinction, since under a given set of projected exogenous conditions, one strategy is readily translated into the terms of the other. For example, a strategy of stabilizing stumpage price increase at 5% may, under a fixed set of external conditions, be equivalent to a strategy of stabilizing end product price increase at 4%. The principal concern here is for the degree or extent of stabilization efforts. Under stumpage price stabilization, an agency sets some objective for stumpage price increase, accepting whatever increase rate that results in end product prices.

Proposals Examined

Two specific price stabilization strategies based on stumpage supply are examined in the following sections. The period of simulation analysis runs from 1975 to 2000, with strategies being implemented in 1978. In both strategies, only the levels of national forest timber harvest in the western regions are varied. National forests in the East could sustain little increase in harvest due to the lack of any significant excess volume in merchantable diameter classes. Private timber harvest varies in the analysis depending on price and inventory conditions, but no specific strategies to increase private supply are examined.

The first strategy assumes a goal of maintaining constant real stumpage prices in the western regions for the remainder of this century. In this strategy, the relative regional mix of western national forest harvests is not fixed but is set as needed to obtain the desired price levels. The second strategy attempts to maintain constant end product prices. In calculating the volumes of national forest harvest required to meet strategy objectives, we set the relative regional mix of harvest in the western regions equal to the mix found for the corresponding year under stumpage price stabilization. Thus, the two strategies differ only in the price used as a criterion.

The base for comparison with the two price stabilization strategies is a continuation of the "current" method of calculating allowable harvests. Continuation of this strategy is assumed to result in future annual harvest levels on national forest lands in the western regions that are equal to the annual harvest levels observed for the period from 1970 to 1974.

Model of the Forestry Sector

The alternative stabilization strategies are examined by policy simulations with an econometric model of the U.S. softwood stumpage, lumber, and plywood markets. An outline of the structure of the model is presented in figure 1. We estimated model parameters by two-stage least squares with a reduced number of first-stage instruments, using annual data for the period 1947 to 1974. This section describes the elements of the model in general terms. Further details of the model and its development are given in the study by Adams.

Four domestic softwood supply regions are recognized: western coastal (WC), western pine (WP), southern pine (SO), and northern.[4] Production of softwood products in the northern region is relatively minor and is taken as exogenous. Supply relations are developed for lumber and plywood from each endogenous region and for softwood lumber imports from Canada. The model does not distinguish among domestic demand regions. Thus, for a

[4] The western coastal region includes western Washington, western Oregon, and the California redwood area. The western pine region consists of all states west of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas (except for the western coastal region). The southern pine region comprises the twelve states from Virginia to Texas. The northern region comprises the remaining states north of the southern pine region and east of the western pine region.

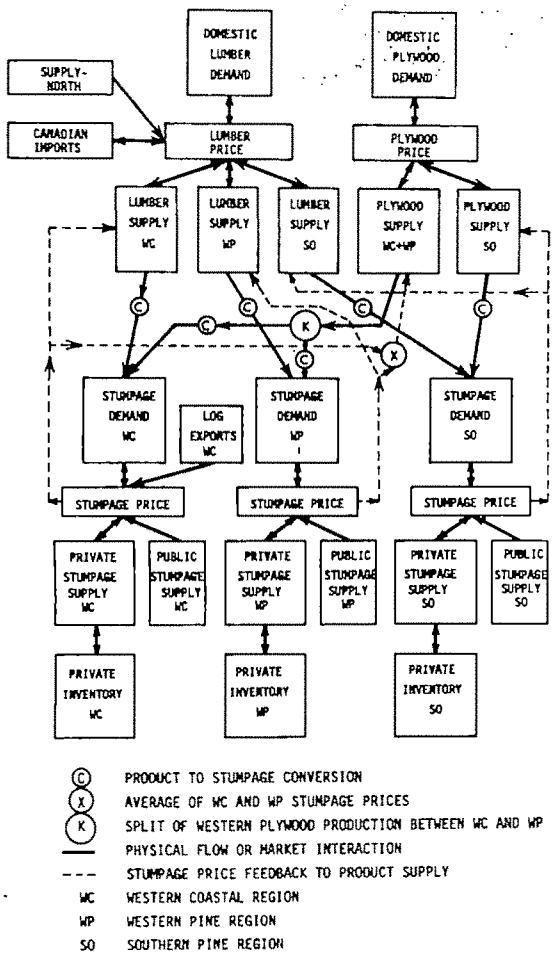


Figure 1. Structure of the model of the softwood timber market

given product, regional and import supplies are assumed to enter a single, national market where equilibrium price and volume are determined by the interaction of aggregate (regional plus import) supply and aggregate (domestic plus exogenous export) demand. Transportation costs between producing and consuming regions are not explicitly considered in the model. However, transportation costs and other factors that determine regional competitive advantage are reflected in the time-series data used to estimate the model. Thus, the model, although regionally disaggregated on the supply side, is nonspatial. Stumpage is a factor in the production of softwood lumber, plywood, and other products and is explicitly considered by our modeling the stumpage market separately for each supply region.

Demand Elements

Softwood lumber and plywood are the only end products treated as endogenous. Consumption of softwood pulpwood, miscellaneous products (such as shingles, poles, etc.), and fuelwood is considered exogenous. Harvests for these products enter the model as additional demands on regional stumpage markets.

Demand equations for softwood lumber and plywood contain variables reflecting the level and changing composition of housing and other industrial activity. These equations also contain relative price terms to account for substitution among wood and nonwood substitutes for softwood lumber and plywood.

The demand for stumpage by lumber and plywood producers in each supply region is derived by converting product output volumes to stumpage equivalents. This conversion assumes that softwood lumber and plywood are made from fixed proportions of stumpage and other inputs. Exogenous (price inelastic) components of harvest for pulpwood, miscellaneous products, fuelwood, and log exports are added to lumber and plywood stumpage demand to obtain aggregate regional derived demand for stumpage.

Supply Elements

The supply of either lumber or plywood refers specifically to regional production at the mill level. Market activities at the wholesale and retail levels are ignored, as are inventories at all market levels. Supply relations are developed for softwood lumber for each endogenous region, for southern pine softwood, and for softwood plywood from the combined western (coastal plus pine) regions. All supply relations are of the simple partial adjustment form and include the current product price, regional stumpage price, a regional wage rate variable, the price of petroleum products as an indicator of energy costs, a one-year lagged supply term, and, in the plywood equations, indicators of labor productivity. Division of western plywood output between western coastal and pine regions is taken as a function of relative production costs (stumpage and labor) in the two regions.

Stumpage supply is defined as the volume of timber made available for immediate harvest. In each region, stumpage supply is disaggregated into public and private components.

Public supply, comprising harvests on national forests and lands owned by other federal, state, and local governmental agencies, is taken as exogenous. Private stumpage supply equations relate harvest to stumpage price and private stumpage inventory. Inclusion of this latter variable assumes that harvesting costs vary inversely with the level of inventory. When inventories decline, as has been the case in the western regions, transportation distances increase, logging conditions become more adverse, and stands are generally of lower volume per acre. With increasing inventories, which is the general condition in the southern pine region, these trends are reversed. Thus, private harvest fluctuates directly with levels of private inventory. Over time, however, sufficiently large changes in price can shift harvest up or down, regardless of trends in inventories. Thus, increasing harvest in the face of declining stocks, as observed on private lands in the West, is a feasible outcome of the model.

The level of private cut determined in the stumpage market represents total product output from private timberlands. These volumes are adjusted to obtain estimates of total removals from the live timber inventory. A separate set of relations for each region adjusts private inventory for these removals, natural mortality, and growth, yielding an updated inventory figure for use in the following period. Relations describing inventory dynamics derive from work by Larson and Goforth.

Trade

Lumber exports to all countries and imports from countries other than Canada, together with plywood imports and exports, are taken as exogenous in the model. Absolute levels of these trade flows are small (less than 5% of domestic consumption in each case) and involve a large number of countries. Softwood lumber imports from Canada, on the other hand, are large (more than 20% of domestic consumption) and seem likely to grow in the future. Canadian import supply was modeled as a function of a moving average of relative Canadian and domestic lumber prices and a lagged imports term.

Measures of Program Impact

The objective of the welfare analysis in this paper is to estimate the distribution of gains and losses between consumers and producers and among consuming regions resulting from the adoption of price stabilization programs. We have followed King's suggestion in attempting to identify as many impacts as possible on the parties involved in the forestry sector. For the most part, various measures of changes in expenditures, economic surplus, and values of stocks have been employed. Such measures are incomplete and at best only indicators of actual changes in welfare.

Impacts of the price stabilization programs are measured by the effects of shifting from one discretionary supply policy to another. The impacts are measured relative to the current strategy, which represents a continuation of current methods of calculating the harvest. The prices, production, and consumption levels projected under this strategy are not those that would result from a competitive market equilibrium solution. Thus, the estimates of welfare and other impacts cannot be interpreted as deviations from some socially optimal condition. (See Currie, Murphy, and Schmitz for elaboration on the uses of competitive equilibria as optima in empirical welfare analyses.)

Estimates of welfare impacts on consumers and producers of end products are restricted to lumber and plywood and do not consider effects on pulp and paper and miscellaneous products. Errors introduced by ignoring the latter category are minor, since the volumes involved are extremely small (less than 4% of total softwood roundwood production). The pulp and paper industry, on the other hand, consumes large volumes of softwood products. However, consumer demand for paper products and producer demand for stumpage are both highly inelastic with respect to price (USDA Forest Service 1973). As a result, changes in consumers' welfare for this product group are likely to be small and positive with only limited changes in product price and volume consumed. Impacts on producers' welfare, however, may be somewhat larger, given relatively inflexible product prices and varying stumpage prices.

A similar problem arises in connection with the effects of changes in wood products prices on the consumption and production of nonwood products. An attempt is made to account for reductions in consumers' expenditures on nonwood substitutes. No satisfactory approximations were developed for the potential reduction in the producers' surplus of nonwood substitutes.

Impacts Considered

It is customary to gauge consumer welfare effects by means of shifts in consumers' surplus. (See Currie, Murphy, and Schmitz for an extensive examination of consumers' and producers' surplus and rent and their use in empirical welfare analysis and Willig for conditions under which measures on ordinary demand functions provide useful approximations of the compensatory and equivalent variations in consumer income.) Under a price stabilization program based on stumpage supply augmentation, prices should be lower and volumes consumed higher than in the absence of price control. The associated change in consumers' surplus is expected to be positive and can be measured as the change in consumer expenditures on both lumber and plywood between the current and the price stabilization strategies.

The demand for lumber has been estimated in the model, however, to be perfectly inelastic with respect to prices in the current period but to respond to a moving average of relative lumber and substitute prices in previous periods. Thus, in general, at any point after the initiation of price stabilization strategies, the lumber demand function has shifted relative to its position under a continuation of current trends. This is illustrated in figure 2, where D_0 is demand under a current strategy and D_1 is demand with stabilization strategy initiated in some prior period. Under these conditions, the change in consumers' surplus cannot be calculated, since the area between D_0 and D_1 and above P_1 is not finite. As an alternative, the change in consumer expenditures (the area $A + B - (B + C) = A - C$ in figure 2) on both lumber and plywood was calculated and used as a substitute for the change in consumers' surplus.

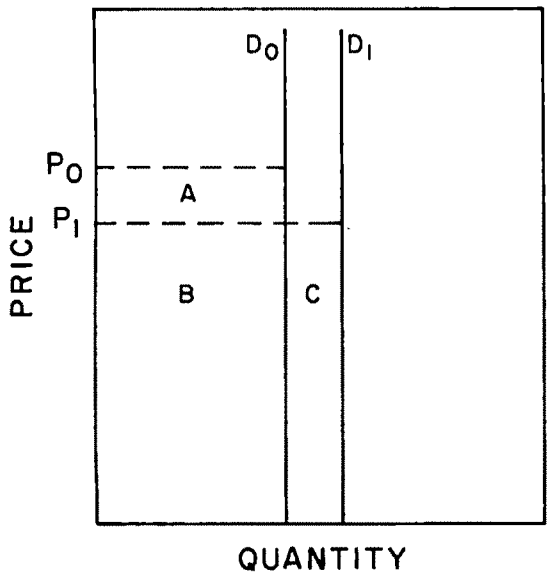


Figure 2. Measures of consumer welfare

A decline in the prices of lumber and plywood entails reductions in consumer expenditures on substitutes. McKillop argues that the increase in consumption of wood products (resulting in this case from the price control program) evaluated at the lower prices prevailing after the shift in supply is a reasonable estimate of the reduction in expenditures for substitutes (area C in figure 2). After we employ a similar approximation here, the estimate of net change in expenditures for lumber and plywood reduces to the product of the change in price and the original volume consumed in the absence of a price control program. This is area A in figure 2.

Examination of welfare impacts on producers is more complex because of the regional structure of the lumber and plywood industries and because both stumpage and end product markets are considered. Direct welfare impacts on producers of lumber and plywood have been estimated for each endogenous region by means of changes in producer surplus. Net change in national producer surplus is estimated as the sum of shifts in each region, excluding the exogenous northern region. This region produces no softwood plywood and less than 5% of total national softwood lumber output; only 1/3 of 1% of its softwood inventory is in federal ownership. As in the South, northern softwood lumber producers face lower product prices under price stabilization with no concomitant expansion in stumpage supply. Producer surplus for the northern region would probably decline, making the estimate of aggregate national change in producer surplus across all regions somewhat high.

Potential difficulties arise in the calculating changes in producers' surplus in the stumpage market, since some forest products firms produce both stumpage and end products. Integrated firms are assumed to value their own stumpage at equilibrium market prices. This eliminates possible "double counting" involved in considering both an end product and a stumpage surplus for these producers.[5] The

[5] For purposes of federal tax calculations, integrated firms are required to value stumpage cut from their own lands at "market prices."

total surplus of integrated firms is divided between processing and stumpage-growing operations.

In addition to direct consumer and producer impacts, price stabilization strategies may also lead to changes in the value of timber sales receipts to the Federal Treasury and to state and local governments. Each country receives 25% of the net receipts from national forest timber sales within the country's borders. The prices that state governments receive from the sale of timber on state lands is also affected by the change in national forest harvest. The total impacts can be computed and constitute a rough estimate of further welfare gains or losses to both consumers and producers. The exact amount of the impact on state and local governments cannot be estimated because of uncertain local, state, and federal taxation shifts included by the change in revenues.

As prices and levels of end products output vary under a price stabilization strategy, payments to the variable factors of production (including stumpage, labor, energy, and so on) also change. Measures of returns to and surpluses of stumpage suppliers have already been discussed. In both the lumber and plywood industries, the largest component of the remaining nonstumpage costs is labor.

Some estimate of returns to nonstumpage variable factors is of considerable interest, since it gives an indication of the magnitude of changes in direct payments to households. These returns have been calculated here by deducting payments to stumpage from total variable costs. The latter was computed as the area under regional industry supply curves at the various levels of projected industry output. Estimates are not reported for the southern pine plywood industry owing to the highly tentative nature of the supply relation.

The remaining producer impact considered in this analysis is the change in the value of private stumpage inventories induced by shifts in stumpage price under price stabilization strategies. Inventory valuation effects occur at all market levels under price stabilization strategies. In stumpage production, however, the effects on real wealth of producers may be substantial, since rather large volumes of merchantable timber are carried even in the most efficient operations. Under a price stabilization strategy, reductions in stumpage prices lead to an uncompensated "windfall loss" for stumpage producers, which may have some impact on their net welfare positions quite apart from gains or losses in producers' surplus. These shifts are measured as the differences between values of merchantable timber inventories with and without a price stabilization strategy.

Results

Average rates of end product and stumpage price increase over the control period are shown in table 1 for the three simulations.[6] As expected, stabilization of real prices of end products requires a reduction in real stumpage prices in the West by the year 2000. Very large stumpage price reductions are obtained in the WC region, since both stabilization strategies act to offset a sharp declining trend in regional harvest projected under the current strategy.

Because of continued expansion in end product demand and declining inventories on private lands in the West, steady increases in the Forest Service cut are required to stabilize prices in both simulations. By 2000, the Forest Service cut under the price stabilization strategy for end products is 2.8 times the cut under current strategy, but the price stabilization strategy for stumpage levels is 2.6 times higher. Substitution of public for private cut in the western regions is extensive during the first decade of attempting to stabilize prices. This serves to accelerate the expansion of private inventories in the WP region and reduces the rate of private inventory depletion in the WC region. As a result, private harvest does not decline as rapidly toward the end of the control period as was the case under the current strategy, and in the WC region private cut actually increases after 1995 after either of the stabilization programs is implemented. These developments in private cut and inventory reduce the needed expansion in the Forest Service cut between 1990 and 2000.

Production and consumption levels of the stabilization programs are indicated in table 2. Differences between the two programs are minimal. Expansion of national forest harvest in the West reduces stumpage costs, increases

[6] The simulation procedure employed to obtain the market and welfare impact estimates is as follows. First, a set of current levels for the endogenous variables is established by simulating market behavior over the simulation period for a given set of projections of the exogenous variables. These latter projections are detailed in Adams. Then, each stabilization strategy is simulated changing only the levels of Forest Service cut as appropriate for the strategy. All other exogenous variables are held constant. The resulting changes between stabilization and current simulations are taken as the effects of the shift in Forest Service cut.

Table 1. Average Rates of End Product and Stumpage Price Increase under Alternate Strategies, Target Year 2000

Price Index	Strategy		
	Current Market Procedures	End Product Price Stabilization	Stumpage Price Stabilization
	%/Annum		
Softwood lumber	1.22	—[a]	0.15
Softwood plywood	2.69	0.03	0.42
Lumber and plywood	1.46	0	0.19
Stumpage			
WC[b]	3.47	−0.80	0
WP[c]	2.88	−0.48	0
SO[d]	2.26	0.03	0.36

[a] Between 0 and −0.01% per annum.
[b] Western coastal region: western Washington, western Oregon, the California redwood area, Alaska, and Hawaii.
[c] Western pine region: all states west of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas (except for the western coastal region).
[d] Southern pine region: the twelve states from Virginia to Texas.

aggregate end product output, and allows a substantial increase in aggregate consumption. The largest increases are realized in plywood because of its higher demand elasticity and sensitivity of plywood supply to changes in costs.

Under the current strategy, the two western regions are projected to lose market share (regional production as a percent of U.S. consumption) to the southern pine region and to imports in both lumber and plywood. The WC region, which faces a major long-term decline in private harvest, suffers the greatest loss. Institution of either stabilization program sharply reverses this trend in market share for the West, with the greatest gains realized by the WP region. Production and market share continue to decline for the WC region but somewhat less rapidly than under continuation of the current strategy. The SO region faces declining product prices and no corresponding expansion of internal stumpage supply under the stabilization programs. As a result, end product output and market share in the region fall relative to expected shares under continuation of the current strategy. Under end product control, for example, SO lumber production by the year 2000 is 54% below levels for the current strategy. Although production in the region is depressed under control, it does exhibit some growth, and at no point during the remainder of the century does output of either lumber or plywood fall below precontrol (1975–78) levels.

Table 2. Production and Consumption Levels under Alternate Strategies, 1980 and 2000

Activity, Product, and Region	Strategy					
	Current Market Procedures		End Product Price Stabilization		Stumpage Price Stabilization	
	1980	2000	1980	2000	1980	2000
Production						
Lumber						
WC[a] (billion bd. ft.)	10.5	8.4	11.4	10.8	11.3	10.7
WP (billion bd. ft.)	8.5	9.4	8.9	17.6	8.6	16.3
SO (billion bd. ft.)	7.3	14.7	6.5	6.8	6.7	7.8
Plywood						
Western (billion sq. ft.)	11.1	12.7	13.1	27.8	12.6	25.9
Southern (billion sq. ft.)	8.6	14.3	8.5	13.1	8.5	13.3
Consumption						
Softwood lumber (billion bd. ft.)	36.0	45.5	36.1	47.6	36.0	47.3
Softwood plywood (billion sq. ft.)	19.2	26.5	20.7	40.4	20.7	38.7

[a] Regions defined in table 1.

Table 3. Welfare Impacts of Stabilization Strategies Expressed as Deviations from Current Strategy Levels

Type of Impact	Stumpage Price Control Program		End Product Price Control Program	
	1980	2000	1980	2000
	Millions of 1975 Dollars			
Consumer expenditures—total[a]	913	5,851	1,216	6,695
Lumber	506	3,161	695	3,638
Plywood	407	2,690	521	3,057
Producer surplus—total	−471	−1,425	−510	−1,667
WC[b]				
Lumber	172	222	179	224
Plywood	163	1,339	185	1,454
Stumpage	−431	−822	−347	−939
WP				
Lumber	5	829	53	1,046
Plywood	13	474	22	455
Stumpage	−49	−268	−103	−308
SO				
Lumber	−82	−789	−110	−866
Plywood	−179	−1,348	−227	−1,524
Stumpage	−83	−1,062	−162	−1,209
Net welfare impact	442	4,426	706	5,028
Returns to nonstumpage factors in lumber production				
WC[b]	197	584	229	639
WC	−21	293	−9	302
SO	−93	−967	−128	−1,112
Net Forest Service revenues[c]	28	205	1	46
State and county revenues[c]	−86	−298	−119	−400
Private inventory value[c]	−10,014	−25,763	−13,038	−30,490

[a] Expenditure reductions listed as positive values indicate welfare gains.
[b] Regions defined in table 1.
[c] Sum over all regions.

Results of the welfare analysis are shown in table 3 for 1980 and 2000.[7] Net welfare impacts, balancing changes in consumer expenditures and producers' surplus, are positive for both price strategies. Of the two strategies, welfare impacts are larger for the end product price stabilization strategy. Consumers gain under price stabilization throughout the simulation period, and these benefits clearly dominate the net welfare changes. Relative to the current strategy, total end product expenditures are 8% lower under the end product price stabilization strategy by 1980 and nearly 22% lower by 2000.

Changes in producer's surplus are substantially smaller than consumer expenditures and are not uniformly positive. Stumpage producers lose under both forms of price stabilization, since their prices fall with no concomitant reduction in costs. Western stumpage producers incur larger losses at the onset of control, but losses are more nearly equal between the West and the South by 2000. The critical aspects of producer impacts, however, are the nearly offsetting interregional changes in producers' surplus of end products. Western producers realize large gains as stumpage costs fall more rapidly than product prices. Southern producers, facing a similar reduction in prices but a less rapid decline in stumpage cost, suffer losses nearly as large as the gains in the West. Taken together, stumpage and end product changes yield small net losses to producers under both stabilization programs during the simulation period.

The regional pattern of changes in production and producer surplus is repeated in the estimates of returns to nonstumpage variable factors (mostly labor). Employment of and payments to variable factors decline in the South and rise in the West. The trend in net variable factor payments is essentially the reverse of that in producers' surplus. In the case of lumber, losses in the South increase more

[7] Values for intervening years trend smoothly between these two points and were omitted.

rapidly than gains in the West, yielding a declining net return, with losses greater than gains after 1995.

Net Forest Service revenues from timber sales increase under both stabilization strategies. On a regional basis, revenue increments in the WC region more than compensate for losses in the WP and SO regions.[8] Timber sales receipts by states and counties, however, decline sharply. Under price stabilization, Forest Service contributions to local governments are increased, but by less than the decline in the value of the fixed harvests from state and other publicly owner timberlands.

Under both stabilization strategies, rates of private harvest in all regions are substantially reduced and private inventories are somewhat larger than under the current strategy. These volume increments are more than offset by reductions in stumpage prices, resulting in substantial declines in the value of private inventories from current levels. Under end product price stabilization, for example, inventory value (for all regions) is roughly 40% lower than under the current policy by 2000. Total inventory values do not fall below pre-control levels, however, and do continue to increase at much reduced rates under the control programs.

Discussion

On the basis of estimated net welfare changes alone, both stabilization strategies yield substantial net benefits. Consumers consistently gain, while losses by stumpage producers and by end product suppliers in the South are largely offset by gains in the West. Thus, ignoring any concerns for interregional or interpersonal net welfare shifts, we conclude that price stabilization strategies of the form examined here would appear to offer a means of making consumers better off while producers are made at least no worse off than in the current strategy.

Both price stabilization strategies and the current strategy represent alternative courses of public action that may be undertaken beginning in 1978 and continued through the year 2000. Projected market activity under each policy represents distinct alternative developmental paths for the forestry sector.[9] The changes in welfare quantities represent potential gains or losses resulting from the selection of some developmental path other than that implied by the current strategy.

This interpretation is particularly important when one examine the interregional effects of the price stabilization programs. Under the current strategy, western industry continues to decline essentially along historical trends, while industry in the South expands production and acquires an increasing share of domestic markets. With either form of price stabilization, however, the wood cost advantage of the South is eliminated and its potential expansion in lumber and plywood sharply reduced. The welfare analysis suggests a substantial regional redistribution of potential future returns to manufacturing and variable factors of production but does not necessarily imply any major interregional migration of processing capacity or shifts in productive factors. Rather, the migration that might have occurred to the South under the current strategy is now precluded, and additional factors (capital and labor) must be attracted from other sectors to meet the projected requirements for expansion in the West. Indeed, as table 2 indicates, SO lumber and plywood output continues to expand under both stabilization strategies but at a much lower rate than under the current strategy.

The welfare analysis also suggests that real income transfers between producers and consumers are not a major effect of the price stabilization programs. Net producer welfare changes are positive after 1986, and in the period 1978–86 consumer gains are forty to seventy times greater than aggregate producer losses. This results from the inelasticity of end product demand and the relative elasticity of end product supply. Transfers between producer groups, consisting of shifts from stumpage to end product producers, are larger. Prior to 1986, stumpage producer losses exceed gains by end product suppliers, but after 1986, stumpage losses are roughly half of end product gains.

Of the several participant groups examined, stumpage suppliers are the only consistent losers under price stabilization. In all regions, stumpage prices rise less rapidly (or actually fall under end product price stabilization in the

[8] Loss of revenue in the WP region implies an inelastic demand for Forest Service stumpage, a result consistent with the dominance of public timber in this region and the lack of substitute sources.

[9] In effect, the analysis is the sort of year-to-year equilibrium evaluation of alternative policies suggested by Vaux and Zivnuska for forestry programs nearly twenty-five years ago.

West), and the real value of stumpage inventories declines relative to the current strategy. In addition to real income and wealth effects, these losses lead to two further problems of concern to policy makers. The prospect of lower stumpage prices over the next two to three decades under price stabilization reduces timber owners' expectations of the profitability of timber growing and hence the incentive to undertake more intensive silvicultural practices. Although not critical during the simulation period, growth of private inventories would decline as a result, thereby expanding potential price increases when price stabilization efforts end.

This analysis does not identify welfare impacts beyond the year 2000. Either price stabilization program would significantly reduce total timber inventories by 2000 compared with continuation of current policy. The prices of stumpage and end products after the year 2000 would probably be higher under either price stabilization program compared with current harvest policy. Although impacts were not identified beyond the year 2000, their occurrence was recognized. We further recognize that the intertemporal pattern of welfare impacts would be a factor in weighing the choice of a price control strategy.

Second, a slower increase in inventory values may pose important problems for local governments relying on real property taxation as a major source of revenue. The response to this development cannot be predicted, but one outcome might be the shifting of a greater portion of the tax burden to nonforest lands. This problem is further intensified by the projected reductions in direct timber sales revenues by state and local governments noted in table 3.

No deductions have been made in the welfare calculations to this point for the variable costs incurred by the Forest Service in accelerating harvest levels (including costs of timber sale preparation and administration, planning, etc.). Using cost estimates from a Forest Service study (USDA Forest Service 1976) and depending on what is assumed to be included in stabilization strategies in terms of efforts to increase yields, reduce environmental impacts, and other management activities, we find that annual costs might range from as low as $50 million per billion cubic feet harvested to $150 million or more as strategies become more elaborate. If increased timber harvesting costs are deducted from the estimated real income changes, both strategies still yield positive net welfare impacts, even at costs ten times higher than those noted above.

A final concern is the physical feasibility of stabilization programs, i.e., the availability of sufficient timber on the national forests to conduct price stabilization for the 1978–2000 period. Available Forest Service inventory data indicate that old growth reserves alone are adequate to support the end product program at least through 2000.

There are several unique aspects to the analysis of welfare impacts of stumpage and end product price stabilization strategies. First, the volume of timber harvested in one time period affects the flexibility of the program in later periods. The policy maker is faced with the problem of deciding how welfare impacts will be metered out over time. The effect of national forest timber management programs on future generations compared with current generations has been one of the major points of argument in current debates over national forest timber management policy.

Second, the effect on wealth from changes in the value of timber inventories is considerable. In this analysis, the annual effect of either strategy on inventory value amounts to tens of billions of dollars by 2000. Weighing this effect with income and other welfare impacts of alternative programs remains a task for policy makers and the political system.

Third, the strong differential regional effects of price stabilization programs based on manipulation of national forest harvest would probably be a major factor in congressional debates over alternative strategies. Even though the analyst can point out the welfare impacts for each region, the policy maker would have the problem of weighting interregional changes in welfare.

Finally, there are strong pressures in the current political climate against Forest Service initiation of a multidecade program to liquidate old growth timber holdings solely for the purpose of influencing stumpage and end product prices. Interest groups reflecting other forest uses such as recreation, water, and forage would undoubtedly demand a role in determining the objective of timber management. The present study, in identifying and quantifying some of the major welfare impacts, provides a first step in an objective evaluation of the relative merits of price stabilization programs.

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Facilities Location: The Case of Grain Subterminals

Donald A. Hilger, Bruce A. McCarl, and J. William Uhrig

An analysis of a grain subterminal location problem within northwestern Indiana is presented. The problem is solved as a mixed integer program with Benders Decomposition, and discussion is presented on the technique. The empirical analysis concentrates upon the optimum number of subterminals within the region under different assumptions. Upon the concentration of grain in the export market, the results show that initially subterminals reduce costs somewhat regardless of location but as the optimum number is approached location becomes more critical.

Key words: Benders Decomposition, facility location, grain subterminals, mixed integer programming.

The location of facilities within a distribution network is a complex, recurring problem. This article reports on a distribution facility location model applied to the location of grain subterminals in Northwest Indiana. Early approaches to the facility location problem used mixed integer programming. It was later discovered that computational effort and cost could be reduced considerably using heuristic approaches (Elson). This has been particularly true in grain location studies (Ladd and Lifferth, Tyrchniewicz and Tosterud). Geoffrion and Graves have recently rekindled interest in mixed integer programming through the application of Benders Decomposition to specially structured location problems. The grain subterminal facility location problem presented in this paper is formulated and solved using Benders Decomposition. The advantages of the technique are pointed out. The technique should be of general interest to applied economists attempting to solve similar problems.

The study region in Northwest Indiana is a highly concentrated grain-producing area that marketed approximately 126 million bushels of corn and 33 million bushels of soybeans in 1972. Projected marketings used in this study involve 176 million bushels of corn and 47 million bushels of soybeans. The region consists of sixteen counties totaling 6,664 square miles. Currently, several new grain subterminals are being planned and built in the region. Four facilities are in various stages of construction, and two major grain companies have land options on other sites. This has led to a concern within the grain industry about the region possibly becoming overbuilt. This study was begun to investigate the optimum organization of subterminals within the region including an investigation of the factors under which the region would become overbuilt. A critical factor in the optimum organization is the access to export markets. Consequently, analysis is done under two alternative assumptions on the concentration of grain in the export markets.

Problem Formulation and Empirical Specification

The empirical analysis is based upon the following assumptions. Corn and soybeans are combined into an aggregate grain that is shipped from 124 origins through associated country elevators or subterminals, then possibly through subterminals, and finally arriving at thirteen destinations. Country elevators cannot ship to other country elevators nor can subterminals ship to other subterminals. Grain

Donald A. Hilger is an economic analyst with Cargill, Inc., Minneapolis, Minnesota, and Bruce A. McCarl is an associate professor and J. William Uhrig is a professor in the Department of Agricultural Economics, Purdue University.

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supply is adjusted for livestock and immediate local use. The resulting marketed grain supply is fixed by origin, on a monthly basis, as is grain demand by destination. Country elevators receive grain from local origins monthly and either store it, ship it to subterminals, or ship it to destinations. Subterminals receive grain monthly from local origins or country elevators and either store it or ship it to destinations. The analysis considers nineteen possible subterminal locations.

These assumptions lead to a mathematical programming model that minimizes total annual cost of grain movement from the local elevator or subterminal to destinations. Mathematically, the objective function is

$$(1)\quad \min \sum_j FC_j P_j + \sum_t \Big[\sum_i \sum_j C_{ijt} X_{ijt} + \sum_i \sum_k d_{ikt} Y_{ikt} + \sum_j \sum_k e_{jkt} Z_{jkt} + \sum_i b_t H_{it} + \sum_j b_t R_{jt} + \sum_i ME_{it} + \sum_j MF_{jt} \Big].$$

This function minimizes the summed annual fixed cost (FC_j) of opening each of the subterminals (j) times a zero-one variable representing subterminal status (P_j) plus the summed grain handling costs over twelve months (t).

The monthly grain marketing cost components include shipment and storage. Specifically, they are the summation of the costs (C_{ijt}) for country elevator (i) shipments to subterminals (j) times the quantity shipped (X_{ijt}) plus the costs (d_{ikt}) of country elevator shipments to destinations (k) times the quantity shipped (Y_{ikt}), plus the costs (e_{jkt}) of subterminal shipments to destinations times the quantity shipped (Z_{jkt}), plus the country elevator storage cost (b_t) times the volume stored (H_{it}), plus the subterminal storage costs (b_t) times the volume stored (R_{jt}), plus the cost of temporary (one month) storage (M) times the temporary storage used at country elevators (E_{it}) and subterminals (F_{jt}).

Empirically, the nineteen subterminal sites are the locations of four existing subterminals, nine country elevators that are likely candidates for expansion, two sites under consideration by the grain companies, and four sites chosen by the researchers considering grain density. Figure 1 gives the location of elevators and subterminals within the study region. Each of the facilities was specified with capacities for receiving, drying, loading, and storage. The fixed costs of constructing these facilities were calculated using the procedures in Baumel et al.

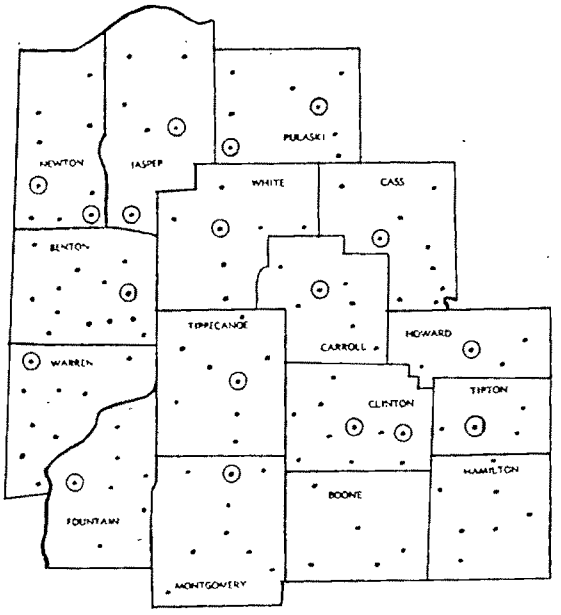


Figure 1. Locations of country elevators and subterminals

The shipment costs were found in a manner also patterned after that used by Baumel et al. and Ladd and Lifferth. Shipment costs consist of transport costs and handling costs. Transportation modes consist of truck and rail. Trucking rates per thousand bushels are $1.37 or $1.90 per mile depending on volume. Rail rates were collected from local grain companies; rates to the East Coast vary from 15¢ to 28¢ per bushel depending on volume.[1] Receiving and drying costs for grain directly from origins are assumed fixed in this study, as they do not vary significantly with the number of subterminals. Handling costs for subterminals were derived from the Baumel et al. study (2.24¢ per bushel) as were load-out costs for country elevators (2.2¢ per bushel) and subterminals (0.56¢ per bushel).

Storage costs consist of the cost of storing grain and the costs of using temporary storage. The cost of storing grain used was based upon the assumption that all stored grain is hedged. Based on a study by Gerke, the cost is fixed at zero, assuming hedging income covers storage costs.

The objective function is maximized subject

[1] Most of the soybeans are used locally, so the rail rates are based on corn shipments and involve one car, three car, five car, and one hundred car rates.

to a series of constraints. The first constraint,

$$(2) \quad \sum_t \sum_i X_{ijt} + \sum_t R_{jt} + \sum_t \sum_k Z_{jkt} \leq \beta_j P_j,$$

requires that total grain handled by a specific subterminal is zero if the subterminal is not constructed ($P_j = 0$) or a large number (β_j; $P = 1$) if the subterminal is constructed. The second constraint,

$$(3) \quad \sum_k X_{ijt} + \sum_k Y_{ikt} + H_{it} - H_{i,t-1} = S_{it} - \sum_j Per_{ijt} SS_{jt} P_j,$$

states that for each country elevator in each month total disposition of grain through shipments to subterminals (X), destinations (Y), or storage (H_t) equals grain received from origins (S) plus the previous month's storage (H_{t-1}) adjusted for the grain that would be diverted to subterminal j if opened ($Per_{ijt} SS_{jt} P_j$).

Empirically, shipments to a subterminal occur from every country elevator within forty miles. Each country elevator ships to every market and every country elevator stores grain. The supply of grain to the local elevators is determined by projecting quantities of grain marketed and then assigning this grain based on country elevator proximity, relative storage capacity, and interviews with industry personnel. The monthly marketing patterns were based upon a 1971 survey conducted by Jones, Sharp, and Baldwin.

The third constraint,

$$(4) \quad -SS_{jt} P_j - \sum_i X_{ijt} + \sum_k Z_{jkt} + R_{jt} - R_{jt-1} = 0,$$

insures that grain disposition is equal to grain inflow at subterminal j during month t. Outflows of grain are shipments to destinations (Z) plus storage (R). Inflows are direct receipts from origins ($SS \cdot P$) plus shipments received from country elevators (X) plus last month's storage (R_{t-1}). Farm receipts of grain are assigned to subterminals in the same fashion as grain is assigned to country elevators. Requiring that

$$(5) \quad \sum_i Y_{ikt} + \sum_j Z_{jkt} = D_{kt}$$

insures that grain received during month t at market k equals demand. Grain receipts consist of direct shipments from country elevators (Y) plus shipments from subterminals (Z).

Empirically, grain demand equals projected grain supplied. The thirteen destinations were aggregated from Jones, Sharp and Baldwin. Grain is allocated to these destinations under different assumptions about exports. The destination locations and their quantities are given in table 1. Monthly assignments were also based upon Jones, Sharp, and Baldwin. The relationship

$$(6) \quad H_{it} - E_{it} \leq Q_i$$

insures that monthly storage used at a country elevator (H) is less than or equal to storage capacity (Q) plus temporary storage (E). Temporary storage is most analogous to piling grain on the ground. The cost incurred and incremental capacity are for one month only. Storage capacity at the country elevators was specified by data obtained from the Indiana Grain and Feed Association. Finally, a sub-

Table 1. Grain Allocations to Destinations under Alternative Export Assumptions

	High Exports		Low Exports	
	Corn (Bu.)	Beans (Bu.)	Corn (Bu.)	Beans (Bu.)
Total market[a]	176,043,710	47,357,211	176,043,710	47,357,211
Logansport, Ind.		8,382,226		8,382,226
Lafayette, Ind.	17,604,370	8,382,226	17,604,370	8,382,226
Frankfort, Ind.		8,382,226		8,382,226
Danville, Ill.	7,041,748	5,493,437	7,041,748	5,493,436
Indianapolis, Ind.	9,858,447	3,978,005	9,858,447	3,978,005
Canton, Ga.	1,760,444		3,520,874	
Memphis, Tenn.	2,816,698		4,929,223	
Louisville, Ky.	21,301,289	710,358	31,863,912	1,657,502
Baltimore, Md.	37,673,353	1,846,931	24,998,213	1,515,435
Norfolk, Va.	26,230,513	1,704,859	20,949,202	1,231,287
Dayton, Ohio	10,034,491	284,143	15,315,802	520,929
Chicago, Ill.	31,687,867	8,050,725	22,885,682	7,482,439
Albany, N.Y.	10,034,491	142,075	17,076,239	331,500

[a] Grain marketed from the sixteen-county study area.

terminal's storage is limited by

$$-V_jP_j + R_{jt} - F_{jt} \leq 0. \tag{7}$$

In this constraint, fixed storage capacity (V) is a function of whether the subterminal is constructed or not.

As the model is specified, there are 19 potential subterminals, 105 country elevators, and 13 final destinations. The model is solved for one year with each of the twelve months included. This led to monthly grain shipment models with 2,371 transport activities, 124 storage activities, and 299 constraints. The resultant annual problem had 19 integer zero-one variables, 31,656 continuous variables, and 3,588 constraints.

Problem Solution

The problem as presented and formulated above is a large mixed integer program that was not solvable on the software readily available. The approach to the problem therefore necessitated the development of a solution strategy. The solution strategy used is based upon the technique of Benders Decomposition. Benders develops a technique that, in optimizing a mixed variable programming problem, decomposes the problem into two separate problems. Global optimality of the overall problem is attained through the use of dual information. In general terms, the approach is iterative, where a solution is proposed by a master problem then tried in the subproblem, which returns dual information to the master problem. The master problem then chooses a new solution based upon the duality information of this and all previous subproblem solutions. The new master problem solution is then returned to the subproblem and the iterations proceed. Termination of the procedure occurs due to bounding conditions. At each iteration involving the master problem the procedure gives a best possible objective value that could be found, and at each subproblem iteration the actual objective function value is computed. These outputs yield a monotonically nonincreasing bound spread, indicating to the researcher the maximum difference from optimality. These topics are discussed further in the appendix.

The application of Benders Decomposition to the grain problem leads to a master problem that consists of the integer-subterminal location variables with one new continuous variable and a subproblem that consists of the grain shipment and storage problem given known subterminal locations.

The master problem objective is given by

$$\min \sum_j FC_jP_j + Z_o, \tag{8}$$

which consists of the fixed cost of subterminal location plus the predicted cost of the subproblem (Z_o). The predicted subproblem cost is gained through the addition of constraints to the master problem, which are given by

$$Z_o \geq \sum_j \alpha_j^l \beta_j P_j + \sum_t \Big[\sum_i \gamma_{it}^l (S_{it} - \sum_j Per_{ijt} SS_{jt} P_j) + \sum_j \psi_{jt}^l SS_{jt} P_j + \sum_k \sigma_{kt}^l D_{kt} + \sum_i \xi_{it}^l Q_i + \sum_j \theta_{jt}^l V_j P_j \Big]. \tag{9}$$

These constraints occur for each solution l of the subproblem that has been done and effectively state that the predicted value of the subproblem is greater than or equal to the shadow prices from the subproblem times its right-hand sides. The right-hand sides, however, are affected by the subterminal location variables. The term α_j^l gives the shadow price for changes in the right-hand side of relation (2) and β_jP_j is the right-hand side passed to the subproblem when the subterminal locations have been chosen. Thus, the term $\sum_j \alpha_j^l \beta_j P_j$ gives the predicted contribution of the constraint on subterminals to the objective function of the subproblem. Similarly, γ_{it}^l is the shadow price from the lth solution of the elevator relationship (3), and $S_{it} - \sum_j Per_{ijt} SS_{jt} P_j$ is its right-hand side. The variables ψ_{jt}^l, σ_{kt}^l, ξ_{it}^l, and θ_{jt}^l are the shadow prices for relationships (4) through (7), respectively. Thus, relationship (9) states that Z_o is greater than or equal to the dual objective of the subproblem, i.e., the right-hand sides times the shadow prices over each subproblem solution. Since Z_o is minimized by the objective (8), it is equal to the best prediction of the subproblems objective. Thus, the master problem equations (8) and (9) represent the overall original problem.

This decomposition then creates two problems that must be solved iteratively.[2] The iterative procedure is: (*a*) choose a set of subterminals, (*b*) solve the grain distribution and

[2] This iterative procedure differs from previous heuristic approaches in that the procedure starts with an initial solution and generates multiple solutions in an optimizing sequence. Thus, a heuristic solution could be used as a starting point, and it could be improved upon.

storage problem, (*c*) form an equation like equation (9) and add to subterminal selection problem, (*d*) solve the subterminal selection problem, and (*e*) take the new set of subterminals and go to (*b*). This procedure continues until the predicted and actual outcomes converge to a degree acceptable to the researcher.

Problem Simplification

Following the application of Benders Decomposition, the two problems created are an integer programming problem with nineteen zero-one variables and a variable number of constraints and a linear programming problem with 31,656 variables and 3,588 constraints. The linear problem is a network problem and would be solvable by special purpose network algorithms (Bradley; Fuller, Randolph, and Klingman) or large linear programming algorithms (Barnes and Crisp). However, these were not available, and a simplification was made. The month-to-month grain distribution problems are connected by the storage variable. This study separates the problem into twelve separate problems, where the storage at time $t - 1$ is taken as given at t. The model thus moves forward in time without backward linkages.[3] Storage in a month is not affected at an elevator by the shipping pattern in succeeding months. This assumption removes guarantees of optimality and leads to solutions where future demands are not considered in current shipping patterns. The assumption may be as realistic as the total model solution wherein an elevator would plan its shipments with perfect knowledge of all twelve months' future demands.

Results

The principal empirical objective of this study is to obtain an optimum subterminal organization. This was done through the solution of a subterminal location problem. Two versions of the problem are analyzed. The versions differ due to assumptions on export demand.

High Exports

Solution of the high export subterminal location problem is accomplished in seventy-nine iterations of the algorithm given above.[4] During these iterations several proposed solutions were entered by the researchers, so the algorithm did not function exactly as presented. An overview of the algorithm performance is given in table 2, which presents the current objective function value, the best found so far, and the bound spread (difference between the best found so far of equation (1) and the current best prediction (8) at selected iterations). At each iteration a feasible set of subterminal locations and grain movements is generated. The algorithm is terminated when the bound spread reaches a point where it amounts to 3.4% of the current objective function value. This indicates that the best improvement in the objective function would amount to no more than 3.4% of the current objective function value. The researchers felt this to be well within the errors in data.

Table 2. Algorithm Performance by Iteration

Iteration	Objective	Best Objective So Far	Bound Spread
1	37,442,620	37,442,620	8,276,847
2	34,668,973	34,668,973	3,121,173
3	33,984,361	33,984,361	2,436,561
5	33,547,882	33,547,882	1,905,887
10	34,779,272	33,547,882	1,800,499
20	33,461,270	33,421,868	1,681,307
40	33,620,552	33,421,868	1,579,188
60	33,277,868	33,245,424	1,282,498
79	33,195,294	33,195,294	1,130,208

The high export problem solution indicates that five additional subterminals should be constructed in the study region. The total annual system cost is $33.2 million, which reflects an annual savings of $400,000 from the existing four subterminals and $4 million from zero subterminals. The majority of the subterminal construction involves the expansion of existing country elevators. The subterminal system selected and the grain flows to these sites are given in figure 2. In this solution, subterminals handle 69 million of the 233 million bushels of grain. The subterminals ship 67 million bushels to the coast (Baltimore and Norfolk), fulfilling these export destinations orders completely. The remainder of the subterminal grain flows principally to Canton,

[3] The same sort of assumption appears to be used in Ladd and Lifferth as they solve with one-month planning models.

[4] The approximate computer cost is $4,000. This attempt is the authors' first use of Benders Decomposition and was unnecessarily costly. The authors feel the cost could easily be reduced more than 90% through the suggestions discussed later involving fewer time periods, a priori constraints, and optimizing with a network algorithm.

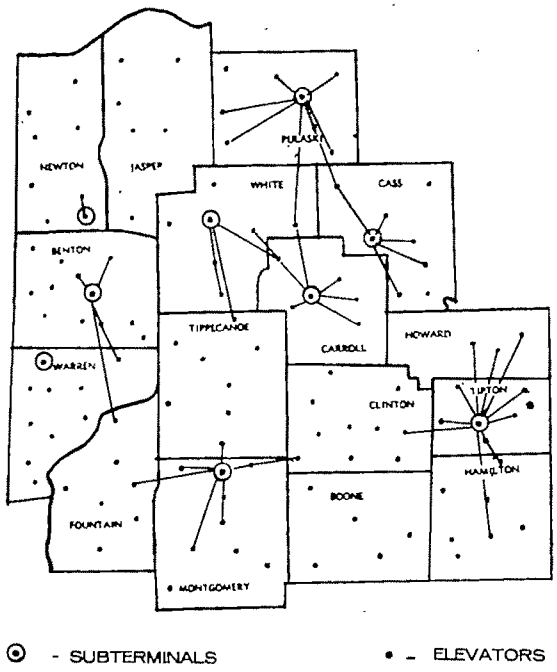


Figure 2. Subterminal placement and grain movement from elevator to subterminal under high export assumption

Georgia (1 million bushels), and Dayton, Ohio (1 million bushels). Country elevators handle 164 million bushels and ship directly to the remaining destinations.

One of the subterminal sites selected in this study was being considered by a major grain company. Subsequent to this study, a subterminal is under construction at this site.

A further concern leading to this study is the possibility of overinvestment in subterminals. Table 3 presents data summarizing all seventy-nine iterations, where the results are grouped by the number of subterminals in solution. The data give the number of observations with a given number of subterminals, the best objective found, the mean of the observations with this number of subterminals, and the standard deviation. These data are presented both in total dollar cost and in cents per bushel.

Several observations may be made on the data in table 3. These observations must be interpreted cautiously, as there are 2^{19} possible locational solutions, and the study only examined seventy-nine. Furthermore, these seventy-nine were part of an optimizing sequence and were not randomly drawn. However, trends emerged that can be pointed out. First, the difference between no subterminals and any subterminals is approximately 1.25¢ per bushel, indicating that subterminals offer significant savings in the grain marketing system. Second, the difference between five and nine subterminals in the region is on the order of 0.2¢ per bushel, indicating a fairly flat total cost curve. Third, the mean of the total cost decreases as the subterminal numbers are increased (within a relevant range), indicating that more subterminals generally reduce the total cost regardless of location. Finally, the standard deviation reaches a minimum at seven subterminals, then increases as more are added, indicating the location becomes more critical as optimality is reached.

In addition to this general overview, an entire solution of the problem is present at each iteration for all of the variables presented above. Further discussion of the results is presented by Hilger. A detailed analysis of the flows and temporary storage indicates other possible subterminal sites. One of these sites is on the fringe of the study region and is currently being considered by one of the large grain companies.

Table 3. Solutions by Number of Subterminals Present

Number of Terminals	Number of Solutions	Best Objective	Cents/Bushel	Mean Objective	Cents/Bushel	Standard Deviation	Cents/Bushel
0	1	37,442,620	16.760	37,442,624	16.760	—	—
2	2	33,924,361	15.212	34,357,366	15.379	3,044,503	1.363
3	5	33,750,136	15.107	34,348,117	15.375	278,665	0.125
4	8	33,547,882	15.017	33,847,849	15.151	172,620	0.077
5	19	33,421,868	14.960	33,681,440	15.077	145,397	0.065
6	10	33,445,769	14.971	33,579,904	15.031	134,811	0.060
7	12	33,245,524	14.881	33,413,174	14.957	71,272	0.032
8	18	33,197,124	14.860	33,389,742	14.946	90,373	0.040
9	3	33,195,294	14.859	33,337,796	14.923	100,912	0.045
All 19	1	34,668,973	15.519	34,668,973	15.519	—	—

Low Exports

Under the low export assumption, seven runs are made to analyze the situation. This analysis is much briefer, as it draws upon the numerical and practical experience gained in the high export analysis. The final low export solution consists of three additional subterminals with a total system cost of $33.9 million (or 14.5¢ per bushel) with a bound spread of $1.32 million or 3.9%.[5]

The solution and grain movement is portrayed in figure 3. The solution represents a cost savings of $3 million from the zero subterminal case and a savings of $400,000 from the nine subterminals found to be optimal in the high export solution. Grain generally flows in the same pattern from the country elevators, although the elevators in the Tipton region tend to ship to Louisville rather than to a subterminal. The grain subterminals handle 53.2 million bushels. Grain shipments involved 47 million bushels to eastern exporters, 3 million to Memphis, Tennessee, and 1.3 million to Dayton, Ohio. The results on overbuilding seem to be consistent with the general trends observed in the high export case.

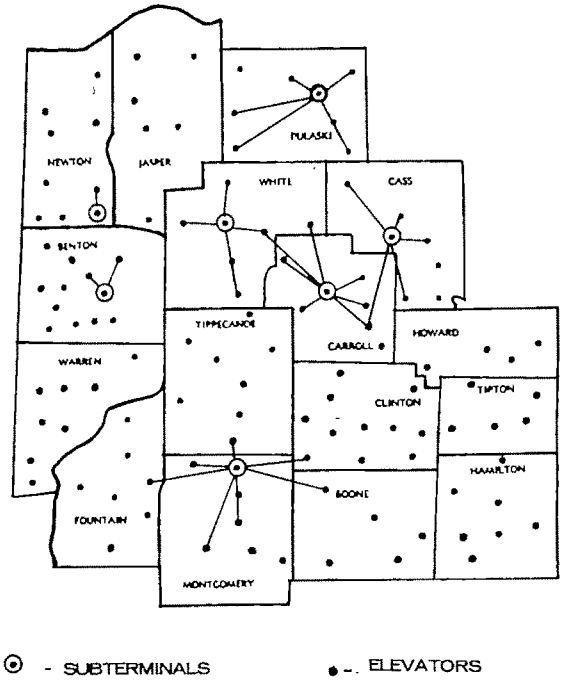


Figure 3. Subterminal placement and grain movement from elevator to subterminal under low export assumption

Concluding Remarks

This article has presented an analysis of a grain subterminal location problem. Details on a formulation, solution algorithm, empirical specification, and solution were presented. General trends were observed with respect to grain subterminals. Summarizing, total cost was significantly affected by the construction of subterminals with annual cost savings accruing to the study region as high as $4 million or 2¢ per bushel. Currently, the region does have four subterminals, and the addition of more subterminals could lead to a further savings of $400,000 or 0.2¢ per bushel. A reasonable amount of subterminal construction appears to yield a cost savings to the region regardless of location. However as an "optimum" number is reached, location becomes a more critical factor.

The specific numerical results of this study should be viewed with caution. In a cost-minimizing framework, subterminals should not be located in close proximity. However, in the real world other factors, both noneconomic and economic, may dictate different arrangements. An encouraging fact, relative to the specific results of this study, is the initiation of construction of a subterminal on one of the sites recommended. Another subterminal is also being considered in a fringe area (to the study region), which detailed model storage analysis indicates is an area where a subterminal could possibly be constructed. There is much detailed information available from the model that is not reported here. In addition, many questions such as rail line abandonment or the effect of new markets may be studied with the model proposed.

Methodologically, this study used Benders Decomposition to solve a large mixed integer programming problem but lost guarantees of optimality through a model simplification. The solution of the high export problem was very costly; however, with the experience generated the low export problem was solved more easily. If the study were to be repeated, the time dimension would probably be aggregated to fewer periods, and the model solved in an optimizing manner. The Benders approach has several advantages over traditional heuristic procedures. Specifically, the heuristics fre-

[5] Computer cost for the low export solution is approximately $200.

quently require detailed implementations for a particular problem (see Ladd and Lifferth, appendix, for example). The Benders procedure used standard mixed integer and linear programming routines with a small interfacing procedure. Benders Decomposition is an attractive solution algorithm and allows quite large mixed integer problems to be solved.

The use of Benders Decomposition allows the researcher to combine judgment with the solution methodology. Experience with the technique by others (such as Danok, Polito, and Geoffrion and Graves) has shown that judgment factors such as the choice of initial starting points, the imposition of a priori constraints on practical settings of integer variables,[6] and the proper choice of solution tolerance lead to faster solutions. The algorithm is applicable to the whole class of facility problems and has been used with machinery selection (Danok) and spatial equilibrium problems (Polito).

From a policy viewpoint, the results of this study seem to present three items of interest. First, the savings due to subterminals are highly dependent upon the rail rate structure and the export market. If the rate differential for unit trains was reduced, much of the attractiveness of subterminals would vanish. Similarly, reduction in exports would dampen the demand for subterminals. However, neither change might not remove the subterminals as they do provide a valuable storage function.

A second item of policy interest concerns overbuilding a region with subterminals. Our numerical data show that, if all subterminals possible in the region were constructed, compared with no subterminals there would be an annual cost savings of approximately 3 million under high exports or 1.3 million under low exports. Compared with the best combinations of subterminals found, if all nineteen subterminals considered were built there would be a loss of 0.8 million with high exports or 1.8 million with low exports. Thus, overbuilding is a less serious problem than underbuilding, although if export demand is projected to drop overbuilding will be of concern.

The third item of policy interest is the approach itself. The study region considered here is relatively small, and the results are location specific. However, the questions asked are common to many regions and the approach used herein appears to be an attractive way of answering such questions.

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[6] An example of this would be to preclude two subterminals that would serve the same region or to impose an absolute limit upon the number of subterminals constructed.

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Appendix

Basic Benders Decomposition

In 1962 Benders developed a mathematical procedure for solving mixed variable programming problems where the variables fall into two sets. A common application of this is mixed integer programming. We briefly review Benders Decomposition below.

The general mixed integer problem can be written in matrix notation as

$$\text{(A.1)} \qquad \min C_1Q + C_2P$$

subject to

$$\text{(A.2)} \qquad A_1Q + A_2P \leq b$$

and

$$\text{(A.3)} \qquad Q \geq 0 \text{ and } P = \text{a vector of nonnegative integers.}$$

This problem may be rewritten as

$$\text{(A.4)} \quad \min \left\{ C_2P + \min \left[\begin{array}{l} C_1Q \\ \text{subject to} \\ A_1Q \leq b - A_2P \\ Q \geq 0 \end{array} \right] \right\}$$
$$P = \text{a nonnegative integer}$$

This version of the problem says that the optimum value of P and Q from equations (A.1) to (A.3) can be found as the simultaneous optimum of C_2P and the optimum value of the bracketed part given P.

Using linear programming duality, the dual of the bracketed part of equation (A.4) is

$$\text{(A.5)} \qquad \max -U'(b - A_2P)$$

subject to

$$\text{(A.6)} \qquad -U'A_1 \geq C_1$$

and

$$\text{(A.7)} \qquad U \geq 0,$$

and equation (A.4) may be reformulated as

$$\text{(A.8)} \quad \min \left\{ C_2P + \max \left[\begin{array}{l} -U'(b - A_2P) \\ \text{subject to} \\ -U'A_1 \geq C_1 \\ U \geq 0 \end{array} \right] \right\}$$
$$P = \text{a positive integer}$$

This reformulation by itself is just a change of variables. Through the duality theory of linear programming, the two problems clearly have the same solutions. The key to Benders Decomposition, which exploits equation (A.8), is the observation that the feasibility (not optimality) of the dual vector in equations (A.5) to (A.7) does not depend on P. Consequently, every possible dual vector is an eligible solution regardless of the setting of the integer variables. Using these facts, the operational Benders procedure involves the iterative solution of two problems.

The master problem is given by

$$\text{(A.9)} \qquad \min C_2P + Z_o$$

subject to

$$\text{(A.10)} \qquad Z_o \geq -U'_l(b - A_2P) \text{ for } l = 1, 2, \ldots, n$$

and

$$\text{(A.11)} \qquad P = \text{a nonzero integer, } Z_o \text{ is arbitrary.}$$

The subproblem is given by

$$\text{(A.12)} \qquad \min C_1Q$$

subject to

$$\text{(A.13)} \qquad A_1Q \leq b - A_2P$$

and

$$\text{(A.14)} \qquad Q \geq 0.$$

The master problem contains the integer variables and an additional variable Z_o, which is constrained by the relation (A.10) to be greater than or equal to the dual objective function value (A.5) obtained from each of the sets of feasible dual vectors.

Thus, Z_o is the predicted best value of the dual objective and the numerical value of equation (A.9) is the best predicted value of the original objective (A.1). The prediction is perfect if one of the dual vectors U_l corresponds to the true optimal solution X in the subproblem. To guarantee this in general would require all possible dual vectors to be present. This is computationally intractable. Thus, the iterative procedure is employed to successively generate dual vectors. Formally, the algorithm is: (*a*) select an initial set of integer variables P, (*b*) solve the subproblem and obtain a dual vector, (*c*) form a constraint (A.10) and add it to the master problem, and (*d*) solve the master problem. Obtain a new set of integer variables and go to (*b*). The algorithm iterates with the master problem, growing by one row at each iteration. The master problem slowly "learns" about the subproblem by building up its stock of information.

At each solution of the master problem, the objective function value (A.9) gives the best solution value that could possibly be found. Over the iterations this forms a monotonically nondecreasing set of lower bounds. At each solution of the subproblem, the actual value of equation (A.1) may be calculated. By taking the minimum value found as the iterations proceed, a monotonically nondecreasing set of upper bounds is obtained. Information is yielded upon the maximum difference from the true optimum at each stage. This provides the user with an easy way to establish a stopping rule and a continual check upon the maximum difference from optimality.

Unemployment Insurance, Estimated Cost Rates, Benefits, and Tax Burden by Type of Farm

Joachim G. Elterich

Unemployment insurance cost rates for newly covered employers and the corresponding tax burden under two sets of tax structures by type of farm are estimated by state. Livestock, dairy, and poultry farmers generally more than support the benefits their workers receive, which is not the case for fruit and vegetable farms. Under experience rating livestock and dairy farms tend to pay the minimum rate in half the states, while the maximum rate applies for fruit and vegetable farms in many states. Benefits received by workers vary also by type of farm and state and tend to be related to the cost rate.

Key words: agricultural labor, benefit payments, costs, unemployment insurance.

The unemployment insurance (UI) system collects taxes on the payrolls of covered employers while employees are working and pays benefits to eligible employees who become involuntarily unemployed.[1] The system is administered cooperatively by federal and state agencies. Federal provisions set minimum basic coverage provisions, qualifying requirements, and taxing procedures. The states' provisions must meet these minimum federal standards to obtain federal assistance and rebates on UI taxes; however, the states are free to exceed federal standards in determining their own particular eligibility requirements and dollar benefit amounts.

Only former employees of covered employers can receive compensation from UI. A covered employer is one who is subject to payment of UI taxes under the Federal Unemployment Tax Act. Covered workers who meet the qualifying requirements are classified as insured workers.[2] However, to receive benefits, a worker must not only meet the qualifying requirements but must have had one or more weeks of compensable unemployment.[3] A worker who meets the qualifications and has at least one week of compensable unemployment is classified as an actual beneficiary. Total actual benefits received by a worker are the product of the weekly benefit amount and the number of weeks of compensable unemployment. Both are subject to limitations and formulae linking employment duration and/or earnings to benefits under the individual state's provisions.

Currently, agricultural workers in all states are temporarily covered under the Special Unemployment Assistance Act of December 1974. Farm coverage was not included in the Employment Security Act of 1970 (PL 91-373). Instead, the Act mandated a "program of research to develop information . . . as to the effect and impact of extending coverage to agricultural labor." The resulting research was undertaken by the Regional Research Committee of NE 58, composed of agricul-

Joachim G. Elterich is an associate professor in the Department of Agricultural Economics, University of Delaware.

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[1] In New Jersey (along with two other states), workers also pay a 0.25% payroll tax.

[2] A worker is considered insured if he has worked sufficient weeks and/or earned sufficient wages (or specified distribution of them) in covered employment during the record year to demonstrate adequate attachment to the labor force under the states' regulations.

[3] A week of compensable unemployment is a week in which a worker is involuntarily unemployed, is available for work on a job of the same or similar nature to that in which he is usually employed, or is able to work and has made a valid claim for benefits.

tural experiment station researchers in twelve states. This interregional unemployment insurance research project initiated surveys of agricultural employers and employees designed to collect the information necessary to estimate the costs of extending UI coverage to hired agricultural workers in the twelve northeastern states and Ohio, Florida, and Texas.

One of the main reasons mentioned as a source of variation in the cost rates among individual states is the differences in the predominant types of farms among the states. In this article the cost rates by type of farm (congruent with the census definition) are estimated using the data collected in the NE project and the UI provisions in effect in 1971. An objective of this study is to determine the average UI tax burden that a farmer actually would experience. The tax burden is determined on the basis of two sets of tax rates established by the states in 1975: one for newly covered employers and the other based on each farmer's experience rating. In addition, the benefits paid to employees are estimated for 1971.

Methods

The cost rate is defined as the ratio of workers' benefits to their taxable wages. This study uses workers' actual employment histories in 1969–70 obtained from the NE 58 study with the exception of Texas. (For more detail on the survey procedures, see Bauder et al., chap. 1 and appendices I–V.) A worker's benefits are determined based on individual state's qualifying and benefit determination statutes in effect July 1971. Taxable wages are defined as the first $4,200 paid during 1970 to a worker by each covered employer. The benefits and taxable wages of a worker are then allocated to a type of farm in proportion to the wages earned. The total benefits and taxable wages by type of farm for all workers within a state determine the farm-type specific cost rate.

The classification of farms by type used in this cross-section study corresponds to the agricultural census criteria. The types of farm considered are livestock, dairy, poultry, tobacco, fruit, vegetable, cash-grain and other field crops combined,[4] and miscellaneous farms.[5] Considering the number of observations, the basis of some of the cost rates is questionable, and they are not used in this study. This includes all the cost rates for states that are based on less than 100 covered workers.

The cost rates by type of farm are estimated for two alternative coverage provisions. An employer is classified as covered if he hired at least four wage items in at least twenty weeks or had a $5,000 or greater payroll during any calendar quarter of the preceding year (henceforth referred to as "4 in 20 or $5,000").[6] This provision was President Ford's proposal for agriculture and was included in most of the bills receiving serious consideration by Congress in recent years.[7]

This study estimates the cost to farmers using two different sets of tax rates for 1975: (*a*) a standard UI tax rate, which is the rate on taxable payroll that newly covered employers must pay (it applies usually for the first three years) and (*b*) the UI tax rate applicable under experience rating that is bounded by a minimum and maximum rate established in each state (Commerce Clearing House). The standard tax rate and the one under experience rating also include the 0.5% federal tax and a solvency factor applicable in some states (table 1).[8] The tax rates that apply to newly covered employers and minimum and maximum tax rates under experience rating used in this study are the tax rates that were in effect in 1975. They are selected to demonstrate their effects upon the tax burdens that farmers would experience on different types of farms in different states.[9]

[4] Cash-grain and other field crops are grouped into one type of farm, since these farms have similar characteristics and individually none of these classifications have sufficient observations for a meaningful analysis. Henceforth, they are referred to as cash-grain farms.

[5] Miscellaneous farms encompass a host of diverse operations; however, some information about this group is preferable to none.

[6] A wage item (worker) is the employment of one worker by one employer during any part of a year.

[7] The estimates for the "1 in 20 or $1,500" provision in force for nonfarm workers are not reported here, since they are not significantly different from the current "4 in 20 or $5,000", but they may be obtained from the author. However, it would be premature to generalize that insignificant variations in the tax burden would occur under all conceivable coverage provisions. The recently enacted Public Law 94-566 specifies a "10 in 20 or $20,000" provision for coverage, which would reduce the number of covered employers and workers appreciably for some types of farms compared with the "4 in 20 or $5,000" provision.

[8] A solvency factor is not added in a state when it has a positive UI fund balance. However, in recent times the balance of the UI fund has fallen below the desired level in some states, and a solvency factor is used to increase the fund's balance by adjusting the tax rate upward. The value of the solvency factors that were in effect in June 1975 are given in table 1. The procedures employed in the solvency factor adjustments are extremely complicated, and their explanation is beyond the scope of this study.

[9] Estimates of the tax burden based on the 1971 tax rates were

Table 1. Tax Rates, Solvency Factor, and Cost Rates under "4 in 20 or $5,000" Coverage Provisions, 1975

	State												
	Conn.	Del.	Fla.	Maine	Md.	Mass.	N.H.	N.J.	N.Y.	Ohio	Pa.	R.I.	Vt.	W. Va.
	%													
Standard tax rate	4.2	4.4	1.5	2.5	2.2	3.5	3.2	3.9	4.2	3.5	2.5	3.2	2.9	2.0
Experience rating														
Minimum	1.9	1.8	0.5	2.4	1.1	4.4	0.6	1.7	1.8	0.7	1.5	2.7	1.5	0.5
Maximum	6.4	4.7	5.0	5.0	4.1	5.6	4.5	6.7	5.5	4.3	4.5	4.5	5.5	3.8
Solvency factor[a]	1.0	1.2	0.001	0	0.6	1.0	0	0.8	1.0	0.2	1.0	1.0	0	0
	Estimated Cost Rates													
Type of farm														
Dairy	3.3	1.7	0.8	0.9	1.3	1.6	0.5	1.6	1.8	0.7	2.0	[b]	0.5	0.5
Poultry	2.5	2.4	2.2	1.2	1.2	2.5	2.4	3.0	3.0	2.5	3.4	[b]	[b]	0.8
Livestock	[b]	[b]	0.6	[b]	1.1	1.5	[b]	[b]	1.5	0.9	1.9	[b]	[b]	0.5
Cash-grain	[b]	10.5	5.9	4.3	1.6	8.2	[b]	11.0	4.3	2.7	4.0	6.6	[b]	0.5
Tobacco	10.5	[b]	1.3	[b]	10.0	3.9	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
Fruit	9.0	2.6	3.2	6.6	7.4	8.1	5.9	9.7	4.5	7.2	5.5	[b]	2.5	2.9
Vegetable	12.2	8.3	4.5	6.0	4.8	6.9	2.7	9.1	4.5	7.6	5.2	[b]	[b]	[b]
Miscellaneous	6.9	5.6	1.7	0.5	2.3	3.1	[b]	7.2	3.1	3.7	3.5	12.0	[b]	0.5

[a] These solvency factors are included in the tax rates.
[b] Data are not statistically reliable as explained in text.

The UI tax rates are subject to annual review and possible revision by the states. The tax rates under experience rating in effect in 1975 are used instead of the less realistic state statute rates. After comparing the two sets of tax rates, it became obvious that the 1975 maximum rate was—with very few exceptions—at or near the maximum statutory rate of the states. On the other hand, only four states approached or were at the statutory minimum rate in 1975. Usually they were at least double the statutory minimum due to fund deficits. Also, for the foreseeable future most states likely will have to charge employers tax rates near the maximum permissible rate in order to replenish their UI fund reserves.[10]

In using the 1975 tax rates, this study assumes the same worker history of farm employers in 1975 as in 1970, since the 1970 survey has not been updated. However, any change that may have occurred since then would change the findings of this study only slightly. Both workers' taxable wages and the UI benefits have increased approximately proportionately. At the same time, the level of employment has remained constant or decreased in most states, and the number of employers with employment sufficient to qualify for coverage has remained constant or increased with the factors involved tending to offset each other. The seasonal employment pattern is judged to have remained essentially unchanged. However, I see no way to judge the changes in employment behavior by both employers and employees since 1971.

The UI costs are the product of the tax rate and the average taxable wage for each type of farm in a state. The average taxable wage per farm is calculated by dividing the total taxable payroll of all farms of a particular type by the number of farms hiring labor, using table 28 of the 1969 *Census of Agriculture* data for commercial farms (U.S. Dep. Commerce). The taxable payroll is the total hired farm labor expense adjusted by a factor. This adjustment accounts for the fact that only the first $4,200 of an employee's wages are taxable. The factor is obtained from the Social Security Administration and varies from state to state and according to the employer's number of workers. The farmers' estimated UI taxes under standard rates and experience rating are expressed as a percentage of production expense and net income (as reported in the 1969 *Census of Agriculture*) and determine the tax burden by farm types and state.

also calculated to assess the variations over time but due to space limitations are not reported here. It is asserted that the tax rates of the two years encompass a wide range of possible outcomes. The 1971 tax rates are available on request from the author.

[10] Under Public Law 94-566 the tax rate increased by 0.2 percentage points for all states on 1 January 1977.

Relationship of Tax Rates to Expenses and Income

Standard Tax Rates

This section analyzes the impact of the UI tax as a proportion of production expense and net income based on the standard tax rates of 1975. The standard tax rates of the survey states range from 1.5% in Florida to 4.4% in Delaware (table 1). For newly covered employers, the tax burden is dependent upon the state's tax rate applicable at the time and the taxable payroll of a particular farm on the one hand and the farm's net income (or production expenses) on the other. In other words, while tax rates vary among states, further variations exist within a state based on net income or production expenses.

Most states would charge dairy, livestock, and poultry farms a higher standard tax rate than needed to maintain the estimated benefits paid to workers on those farms. On the other hand, the standard tax rate (including the 1975 solvency factor) would be insufficient in almost all states to cover the benefits paid on vegetable, fruit, and tobacco farms. The relation between standard tax and cost rate is mixed for cash-grain and miscellaneous farms, i.e., in most states this standard rate is lower than the cost rate, but it is higher in some.

The employers whose cost rates are estimated to be less than the standard tax rate pay a tax that is greater than the cost of providing benefits to their workers under a self-supporting fund. At the same time, the benefits that accrue to workers of those employers whose cost rate is greater than the standard tax rate are subsidized by other employers in their state.

The UI tax burden computed as a proportion of production expense is relatively low for dairy, poultry, and livestock farmers (not exceeding 0.8%) in all states (table 2). The tax as a proportion of net income generally does not exceed 5% for dairy and poultry farms. Though this proportion is considerably higher in some states for livestock farms, it is suspected that farmers on these farms also have off-farm income.

Even though the tax burden for dairy, livestock, and poultry farms is small, these types of farms usually pay a multiple of estimated costs into the UI fund before experience rating can be applied to them. The opposite holds for fruit and vegetable farms in most states and for tobacco, miscellaneous, and cash-grain farms in some states. By paying into the fund under the standard rate—before experience rating affects their cost rate—these farms pay only a fraction of the estimated cost. For tobacco, fruit, miscellaneous, and vegetable farms, the UI tax as a proportion of production expense and net income was relatively high in most states (between 0.5% and 1.8% and 2.3% to over 20%, respectively). The tax in relation to net income was also high in some states for cash-grain farms.

For all types of farms, the variability of the UI tax as a proportion of production expenses among states is small (three- to six-fold); however, it is very high for the proportion of net income, especially for cash-grain, livestock, and tobacco farms (up to thirty-fold).

Experience Rating

This section discusses the tax rate and burden under experience rating by type and state. The employer's estimated cost rate under experi-

Table 2. UI Tax as Proportions of Production Expenses and Net Income per Farm, 1975

Type of Farm	Average Taxable Wage per Farm ($)	Standard Tax Rate: Average UI tax as a Proportion of Production Expense	Standard Tax Rate: Average UI tax as a Proportion of Net Income	Experience Rating: Average UI Tax as a Proportion of Production Expense	Experience Rating: Average UI Tax as a Proportion of Net Income
Dairy	1,331– 32,358	0.22–0.62	0.62– 2.77	0.07–0.61	0.12– 2.28
Poultry	2,499– 9,879	0.09–0.59	0.58– 5.32	0.05–0.74	0.31– 5.91
Livestock	857– 3,801	0.19–0.84	0.94–20.41	0.05–1.06	0.24–11.12
Cash-grain	693– 10,985	0.31–0.83	0.45–15.28	0.08–1.37	0.10–26.33
Tobacco	1,255–123,861	0.48–1.90	0.81–14.11	0.41–2.90	1.18–21.51
Fruit	5,008– 34,160	0.45–1.98	2.00–27.31	0.80–2.76	4.26–17.33
Vegetable	3,594– 30,991	0.34–1.46	1.73–11.43	0.83–2.47	2.39–19.64
Miscellaneous	3,877– 24,950	0.69–2.31	3.09–17.32	0.24–3.27	0.77–21.30

Note: The data by states for each farm type are available upon request from the author.

ence rating is limited in each state by established minimum and maximum tax rates. Within these limits, the burden is determined by the cost rate and the taxable payroll of the farm and the specific net income (or production expenses) of the farm. The payroll is farm (type) specific and depends on the level of wages and the size and duration of employment of the work force. Assuming an employer's computed cost rate exceeds the state's maximum tax rate, the excess of his workers' benefits over the employer's contributions is financed indirectly by increasing the tax rate and hence contributions of other employers who pay less than the state's maximum tax rate. Assuming an employer's cost rate under experience rating is below the minimum tax rate, he pays a tax greater than his employees cost the UI program. The employers who have a computed cost rate under experience rating between minimum and maximum tax rate are fully supporting the program.

In 1975 the minimum tax rate under experience rating ranged from 0.5% in West Virginia and Florida to 4.4% in Massachusetts, and the maximum tax rates ranged from 3.8% in West Virginia to 6.7% in New Jersey (table 1). The minimum tax rate applied to at least one type of farm in each state. In Massachusetts, the 1975 minimum tax rate applied to all types of farms, except fruit and vegetable. In Vermont and New York, the 1975 maximum tax rate was greater than the cost rate for all farm types considered.

Under experience rating, the UI tax burden is low for dairy, livestock, and poultry farms, ranging from 0.05% to 1.1% as a proportion of production expenses and generally not exceeding 6.0% as a portion of net income (table 2). Corresponding ranges are higher for miscellaneous vegetable, tobacco, and fruit farms, reaching 3.3% and 21%. However, the lowest proportions for these types of farms may be below 1%. The burden in relation to production expenses is generally low for cash-grain farms but may exceed 20% in relation to net income.

Contributing factors to a low tax burden are year-round employment of covered workers, their earnings level in relation to benefits received, low benefit levels (weekly benefit amount and duration), and a stringent employment or earnings requirement to qualify for benefits. Family farms with zero or only occasional help who do not qualify for UI benefits experience a very low tax burden. Further, if the payroll or UI contributions are a small proportion of net income and/or production expenses, the burden is naturally lower than in the reverse case. Seasonal variations in employment of covered workers, high benefit levels (weekly benefit amounts and durations), and liberal qualifications for benefits increase the tendency for high proportions. Dairy, livestock, and poultry farms usually have a small but year-round work force with high taxable wages but few workers qualifying for benefits. Fruit, vegetable, tobacco, and miscellaneous farms tend to employ a large seasonal work force of which a large proportion collects high benefits. The tax burden is determined largely by the type (and size) of farm and its employment pattern, aside from the state's UI statutes.

Regression analysis indicates that intra- and interstate differences of the cost rates for poultry, miscellaneous, and cash-grain farms tend to be smaller if the states' UI statutes are uniform, since they have equal weight in determining the cost rates with work force characteristics such as earnings, seasonal employment, and farm sales (Elterich and Bieker 1975a, Petty). The cost rate of vegetable, fruit, and dairy farms are much more dependent on work force characteristics than on UI system variables.

Benefit Payments to Agricultural Employees

One of the primary purposes of extending UI coverage to agricultural employers is to reduce individual workers' personal income loss from involuntary unemployment. It also provides an anticyclical effect in case of local or national recessions and stabilizes farm employment. However, the extension of UI coverage to agriculture will undoubtedly have other economic and social implications. Although the exact magnitude of the changes cannot be determined until after the coverage is implemented, some evidence with respect to benefit payments is available.

Table 3 shows the benefit payments in dollars and as a proportion of average earnings for the survey workers by type of farm. The findings indicate that the benefits increase the earnings of workers in some types of farms substantially more than in others. The benefits as a proportion of average earnings of the workers are usually the least on dairy farms, ranging from zero in New Hampshire and West Virginia to 13% in Vermont.

Table 3. UI Benefits, Average Earnings, and Benefits as a Proportion of Earnings,[a] 1971

State	Dairy	Poultry	Livestock	Cash Grain	Tobacco	Fruit	Vegetable	Misc.
Conn.								
Avg. benefits ($)	464	266	[b]	[b]	553	511	539	525
Avg. earnings/worker ($)	4,126	3,482	[b]	[b]	1,977	2,905	1,891	4,030
Benefits/earnings (%)	11.2	7.6	[b]	[b]	28.0	17.6	28.5	13.0
Del.								
Avg. benefits ($)	168	84	[b]	333	[b]	948	397	476
Avg. earnings/worker ($)	3,692	3,328	[b]	2,695	[b]	2,974	3,119	3,261
Benefits/earnings (%)	4.6	2.5	[b]	12.4	[b]	31.9	12.7	14.6
Fla.								
Avg. benefits ($)	122	395	216	286	268	292	365	252
Avg. earnings/worker ($)	5,025	2,727	4,488	3,321	2,744	3,958	3,626	3,641
Benefits/earnings (%)	2.4	14.5	4.8	8.6	9.8	7.4	10.1	6.9
Maine								
Avg. benefits ($)	47	235	[b]	385	[b]	365	174	0
Avg. earnings/worker ($)	2,635	3,749	[b]	1,937	[b]	2,614	2,115	1,244
Benefits/earnings (%)	1.8	6.3	[b]	19.9	[b]	14.0	8.2	0
Md.								
Avg. benefits ($)	304	0	0	1,144	595	477	899	435
Avg. earnings/worker ($)	3,956	5,330	3,628	12,964	1,510	3,002	2,324	3,381
Benefits/earnings (%)	7.7	0	0	38.6	39.4	15.9	38.7	12.9
Mass.								
Avg. benefits ($)	441	244	50	413	371	589	406	753
Avg. earnings/worker ($)	5,196	3,392	4,424	2,239	2,481	3,145	3,335	4,861
Benefits/earnings (%)	8.5	7.2	1.1	18.4	15.0	18.7	12.2	15.5
N.H.								
Avg. benefits ($)	0	278	[b]	[b]	[b]	381	351	[b]
Avg. earnings/worker ($)	2,839	3,772	[b]	[b]	[b]	3,503	1,886	[b]
Benefits/earnings (%)	0	7.4	[b]	[b]	[b]	10.9	18.6	[b]
N.J.								
Avg. benefits ($)	192	391	[b]	393	[b]	693	573	550
Avg. earnings/worker ($)	3,809	4,099	[b]	3,257	[b]	2,741	2,699	3,062
Benefits/earnings (%)	5.0	9.5	[b]	12.1	[b]	25.3	21.2	18.0
N.Y.								
Avg. benefits ($)	135	322	0	270	[b]	335	285	387
Avg. earnings/worker ($)	2,978	3,546	4,665	3,093	[b]	3,612	2,882	4,973
Benefits/earnings (%)	4.5	9.1	0	8.7	[b]	9.3	9.9	7.8
Ohio								
Avg. benefits ($)	174	646	0	648	[b]	366	371	468
Avg. earnings/worker ($)	4,176	3,470	2,977	2,269	[b]	1,478	1,750	3,485
Benefits/earnings (%)	4.2	18.6	0	28.6	[b]	24.8	21.2	13.4
Pa.								
Avg. benefits ($)	249	436	493	269	[b]	376	282	299
Avg. earnings/worker ($)	3,217	3,419	3,144	2,874	[b]	2,945	2,725	3,828
Benefits/earnings (%)	7.7	12.8	15.7	9.4	[b]	12.8	10.3	7.8
R.I.								
Avg. benefits ($)	[b]	[b]	[b]	304	[b]	[b]	[b]	793
Avg. earnings/worker ($)	[b]	[b]	[b]	3,605	[b]	[b]	[b]	4,537
Benefits/earnings (%)	[b]	[b]	[b]	8.4	[b]	[b]	[b]	17.5
Vt.								
Avg. benefits ($)	434	[b]	[b]	[b]	[b]	840	[b]	[b]
Avg. earnings/worker ($)	3,267	[b]	[b]	[b]	[b]	4,533	[b]	[b]
Benefits/earnings (%)	13.3	[b]	[b]	[b]	[b]	18.5	[b]	[b]
W.Va.								
Avg. benefits ($)	0	425	209	0	[b]	289	[b]	273
Avg. earnings/worker ($)	2,381	2,264	1,963	1,992	[b]	2,656	[b]	2,547
Benefits/earnings (%)	0	18.8	10.6	0	[b]	10.9	[b]	10.7

[a] Comparing the benefits with the average earnings of the beneficiaries provides a better social indicator. However, the earnings of the beneficiaries by type of farm are not available. Since the earnings of all the beneficiaries ($2,800) are less than the earnings of all workers ($3,209), the proportions in the table should be adjusted upward slightly. (Benefits shown are per beneficiary.)

[b] Data are not statistically reliable (see text).

The benefits from UI increase the income of the workers with low earnings by a greater percentage than that of the average worker, and a greater proportion of those with low earnings receive benefits. However, the impact of the benefits on workers' welfare varies by the type of farm employing them. Since only about one-fifth of all workers receive benefits (Seaver and Holt, Seaver et al.), UI has an impact on the welfare of this proportion of the worker population. Workers in Connecticut, Maryland, Massachusetts, New Jersey, and Ohio tend to receive high absolute and relative benefit payments (up to $550 or more or over 20% of average earnings, respectively). This is a result of their work histories and the benefit schedules in these states. In Florida, Maine, New Hampshire, and New York, the benefits in absolute or relative terms are low (less than $400 or less than 20% of average earnings).

The fact that coverage provisions are related to the firm's labor force also makes them selective by commodity. Farms having larger labor forces tend to grow fruit, vegetable, nursery products, and other products causing relatively large seasonal fluctuations in labor demand. Under more restrictive coverage provisions, these firms and their workers tend to remain covered (Bauder et al.).

Conclusions

This study investigated some of the economic consequences of covering agriculture with UI. When less inclusive coverage provisions are studied, the differences between coverage provisions are insignificant, since benefits paid out are proportionately reduced with a smaller taxable wage base (Bauder et al.).[11] Similar proportional tendencies apply when the tax burden in relation to its base (production expenses or net income) is considered among the coverage provisions.

In 1975 newly covered employers would have paid a uniform tax rate on wages, regardless of type of farm, ranging from 1.5% to 4.4% depending upon the state. The tax is then a function of the taxable wages paid by an employer, represented here by the average for a farm type in a state. Livestock, dairy, and poultry farms cost rates were usually less than the standard tax rates. The cost rates were higher than the standard tax rate for cash-grain farms in half of the states and for vegetable, tobacco, and fruit farms in nearly every state in 1975. The same tendencies hold when the 1971 standard tax is applied.

Differences between the tax burdens under standard and experience rates are appreciable, since under experience rating state statutes provide for a range of tax rates based on the costs using employers' employment patterns of up to three years. While vegetable, fruit, and tobacco farms traditionally show peaks and troughs, dairy, poultry, and livestock farms have a more even distribution of employment and fewer layoffs and hence the likelihood of a much lower tax burden than the first group of types.[12] The tax rates and burdens were estimated for an "average" farm, and they may vary widely in accordance with the employment pattern of employers. On the one extreme, a covered employer may have no layoffs, or he may hire workers who are not eligible for benefits due to short-term work or nonavailability for work during the rest of the year and hence pay a very low tax under experience rating. On the other hand, if an employer has a seasonally varying employment pattern with many workers drawing high benefits, he will pay a high tax rate on his payroll.

The average UI benefits workers would receive vary in accorance with the cost rates, from insignificant amounts up to $900 or 40% of their average earnings. Workers on vegetable and fruit farms more often receive the highest amounts—due to seasonal employment, while those on dairy and poultry farms receive the lowest, which is to be expected given their tendency to year-round employment. Most workers in Connecticut, Maryland, Massachusetts, New Jersey, and Ohio could expect relatively high absolute benefit payments in relation to their earnings based on their work histories. In Florida, New

[11] This statement does not hold generally. Research presently under way by the author indicates that, for the very restrictive coverage provision incorporated into PL 94-566, the relationship between benefits paid and taxable wage base changes compared with the provisions studied thus far.

[12] In response to a reviewer's comment, I want to stress that the analysis is concerned with empirical findings derived from the existing state rules and rate structures. We do not analyze what the federal government may mandate in the future, namely, uniform rules and rate structure for all states. Assuming farmers of a particular type are competitively adjusted between states before the differing new tax burden affects producers differently in various states (i.e., a state of equilibrium exists between them and they do not reap excess profits), producers in "low tax" states may very well obtain a comparative advantage over like producers in a "high tax" state after the imposition of the taxes.

York, Maine, and New Hampshire the benefits are relatively and/or absolutely low.

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Benefit-Cost Analysis of a Nonmetropolitan Prototype for Solid Waste Resource Recovery

Fred Hitzhusen and Mark Luttner

This study focuses on the recovery of energy and materials from solid waste at a coal-burning steam-electric plant located in a nonmetropolitan county in Northeast Ohio. The results of the analysis suggest that the resource recovery prototype involving a new solid waste processing facility and modification of the existing steam-electric plant is an economically feasible investment. This conclusion is substantiated by sensitivity analysis of five key technical and economic parameters under four alternative benefit-cost and internal rate of return criteria.

Key words: materials and energy recovery, nonmetropolitan, Ohio, solid waste.

The utilization of land as a depository for man-made waste concerns many people because of its potential contribution to environmental decay and the loss of valuable (particularly nonrenewable) resources. The negative impacts attributed to land disposal of solid waste—landfilling—include water pollution by landfill leachate, blowing of paper and general unsightliness, creation of methane gas and odors, and loss of recoverable materials and energy. These problems are accentuated by the increase in volume of solid waste generated (Brunner and Keller, Schulz) and the decrease in land available for disposal sites. Developments in the field of resource recovery offer an opportunity for jointly addressing the problems of solid waste management and energy scarcity at the local level.

An increasingly attractive process for the partial resolution of these problems appears to be the utilization of solid waste as a supplementary fuel in electric plant boilers. The potential benefits of this process include: less burning of coal (or other fuels) with resultant savings in coal purchases, less need for landfill space, recovery of materials (e.g., ferrous metals) from the refuse stream, and opportunity for a public or private utility to aid a community in resolving its solid waste management problem.

The importance of energy recovery often supersedes materials recovery. Abert, Alter, and Bernheisel state that "resource recovery is economically viable provided the community has an electric utility which can utilize the organic fraction" (p. 1057). A study by the Midwest Research Institute found that the capital investment requirements for fuel recovery were lower than for any other recovery process investigated. The study further concludes that "the fuel recovery concept has the most favorable overall economics of any investigated" (p. 47).

The scale requirements normally associated with resource recovery are substantially reduced in those systems including the recovery of energy from refuse. Scale economies are further reduced by the commercial availability of systems designed specifically for relatively small communities. For example, the resource recovery system in Ames, Iowa, serves a county population of approximately 60,000. According to data from the National Coal Association and a national survey funded by the U.S. Environmental Protection Agency, there are over 300 coal-burning steam-electric generating plants similar to the Ames plant located in the nonmetropolitan areas of the

Fred Hitzhusen is an associate professor, Department of Agricultural Economics and Rural Sociology and the Ohio Agricultural Research and Development Center, The Ohio State University, and Mark Luttner is an economist with the U.S. Environmental Protection Agency, Washington, D.C.

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United States (National Coal Association; Tunnah, Hakki and Leonard).

Recent increases in the costs of conventional fossil fuels (coal, oil, and natural gas) provide the greatest incentive for energy and materials recovery systems. Many indicators suggest a sizable increase in future demand for coal resulting from the electric power industry's increasing reliance on coal and its derivatives. This demand is likely to be accentuated in those areas most susceptible to natural gas shortages, i.e., the Midwest, Northeast, and Mid-Atlantic states. Problems in nuclear power development, refinements in coal gasification technology, and projected absolute increases in energy demand all point to increasing demand for coal (with resultant price increases). Increases in the price of coal and other energy sources will make solid waste an increasingly attractive energy source.

The focus of the study on which this analysis is based is a coal-burning steam-electric municipal power plant located in a nonmetropolitan county in Northeast Ohio. The specific objectives of the original study are: (*a*) to ascertain the technical feasibility of converting the existing power plant facility to include an energy recovery system, (*b*) to complete a benefit-cost sensitivity analysis of the proposed resource recovery prototype to evaluate the technical and economic parameters of importance to resource recovery in a nonmetropolitan location, and (*c*) to determine the potential net reduction in external impacts from implementation of such a system.

The Study Area

The area that provides the focus for this analysis is Wayne County, Ohio. Located in the northeastern quadrant of the state, Wayne County has a population of approximately 87,000. Like many other areas, Wayne County is rapidly exhausting its present landfill space. In addition, these current sites are considered suspect in terms of damage to surface and groundwater supplies, negative aesthetic impacts, and generally poor management techniques. Because the county is an important agricultural area of the state, the cost of land for additional disposal sites is relatively high. Residents in the county's population centers oppose the development of new landfills close to these waste-generation centers.

The city of Orrville located in northwest Wayne County owns and operates a 75-megawatt municipal electric plant, a potential site for an energy and materials recovery system similar to that in Ames, Iowa. Two of the four boilers at Orrville Municipal Power (OMP) are side-fired pulverized coal units of modern design capable (with minor modification) of burning refuse in combination with coal. Based on the range of refuse-to-coal firing ratios (15:85 to 27:75), generally recommended for boilers of this type, OMP could burn the combustible portion from 51% to 84% of the solid waste now generated in Wayne County (Smith, Sutterfield).

The prototype recovery system would include a horizontal hammermill to reduce incoming refuse to optimum combustion size, an air classification process (zigzag columnar or elutriative) to separate the refuse into combustible and noncombustible fractions, a magnetic system to recover ferrous scrap material for sale, processed refuse storage facilities, and refuse-fuel transport and firing mechanisms. The entire system (refuse input and processing) would operate in an enclosed building adjacent to the electric power plant. A detailed technical development of the prototype is presented in Luttner.

Methodology

Benefit-cost methodology was selected for the original study (Luttner) primarily because of the a priori evidence of technological external economies (or indirect benefits) associated with the proposed solid waste resource recovery prototype. For example, landfilling of solid waste in the study area appears to be imposing technological external diseconomies (or indirect costs). A priori evidence also suggests that the appropriate discount rate for solid waste resource recovery may not be some estimate of the market rate of interest (Luttner).

Because of the considerable uncertainty regarding values for the discount rate and several other key parameters, sensitivity analysis is used to evaluate the prototype resource recovery facility. Low, medium ("most likely outcome"), and high estimates are made for key technical and economic parameters to determine their relative impacts on economic outcome. The direct economic benefits of resource recovery included in this analysis are the cost savings of reduced landfill activity,

savings from reduced consumption of coal at the power plant, and net revenues from the sale of recovered ferrous metals. Some attempts were made to measure the indirect benefits of decreased leachate induced water pollution due to reduced landfilling and improved air quality due to the use of low sulfur refuse as fuel. Other indirect benefits such as reduced consumption of virgin materials and of the resources required to produce and transport them are not estimated.

The direct costs for the resource recovery prototype include the initial capital outlay for the processing facility and the power plant conversion. Additional costs are the operating costs of the entire recovery facility, operating costs of a small-scale landfill suitable to accommodate that waste not processed and the residuals material (fly ash) from the power plant boilers, transport costs for refuse delivered to the processing facility, and transport costs for excess refuse and fly ash taken to the small landfill.

Physical measures of reduced landfill leachates and power plant emissions are developed, but it was not possible to get reliable monetary estimates of any of the indirect benefits of the solid waste resource recovery prototype. However, there is no a priori evidence of any significant indirect costs associated with the resource recovery process analyzed. Thus, omission of monetary measures of indirect benefits from the benefit-cost sensitivity analysis results *ceteris paribus* in conservative estimates of the discounted present value of benefits and costs estimated for the resource recovery prototype.

The primary criteria utilized to evaluate the prototype are benefit-cost ratio and net benefits.[1] The benefit-cost ratio is generally appropriate for ranking projects under capital rationing. However, it does not provide information on changes in net worth. Determination of the benefit-cost ratio follows the pattern of Seneca and Taussig:

$$B/C = \frac{\sum_{t=1}^{T}\left(\frac{B_t}{(1+i)^t}\right)}{\sum_{t=1}^{T}\left(\frac{O_t}{(1+i)^t}\right) + K},$$

where B is annual benefits resulting from project, O is recurring costs or annual operating and maintenance expenses incurred, T is the time period over which benefits and costs occur, i is the discount rate, and K is capital outlays incurred in the initial year of the project.

The net benefit criteria provides another measure of the economic feasibility of a given investment and provides for determination of changes in net worth. In multiproject comparisons of varying scale, this criterion favors large-scale projects. The net benefit criterion is derived as follows:

$$\text{net benefits} = \sum_{t=1}^{T}\left(\frac{B}{(1+i)^t}\right) - \left[\sum_{t=1}^{T}\left(\frac{O}{(1+i)^t}\right) + K\right].$$

Alternative (low, medium, and high) values are estimated for five technical and economic parameters judged crucial to the resource recovery prototype. The key technical parameter involved is the refuse-to-coal firing ratio utilized in the combustion process. This ratio determines how much refuse can be fired in the boilers, thereby dictating the processing capacity required in the recovery system. The primary economic parameters are the projected coal price levels, rate of discount, and net ferrous revenue per ton of recovered metal scrap. Initial capital investment, a final parameter, tends to have technical as well as economic dimensions. Table 1 presents these parameters and the values developed to demonstrate the sensitivity of the system.

There is some supporting evidence for the parameter projections used (particularly for the medium values) from previous research, historical data, and consultation with authorities in the various areas. For example, firing ratios are based on the demonstrated capabilities of ongoing energy recovery facilities (Sutterfield) and engineering estimates (Smith). The annual coal price increases are based on analysis by the National Coal Association and historical data from Orrville Municipal Power (Williams). The alternative discount rates are based on the Farmers Home Administration loan rate for solid waste projects, the rate of return of U.S. Treasury bonds, and an opportunity cost for capital in the private sector.

The low estimate for capital outlay is based on engineering estimates (Sharp, Smith) and

[1] For comparative purposes, the original study also included the internal rate of return and pay-out period criteria. Internal rate of return is that rate of discount that makes the discounted present value of net benefits equal to the value of the initial capital outlay. The pay-out period criterion measures the number of time periods (usually years) necessary to recoup the initial capital outlay.

Table 1. Summary of Low, Medium, and High Estimates for Technical and Economic Parameters

	Parameter Projection Estimate		
	Low	Medium	High
Refuse: coal-firing ratio	15:85	20:80	25:75
Annual coal price increase	1975–80:10% 1981–94: 4%	1975–80:12.5% 1981–94: 7%	1975–80:17% 1981–94: 8%
Discount rate (%)	5	9	11
Initial investment ($)	3,284,081	4,105,101	5,131,376
Net ferrous revenue per ton ($)	15.00	22.00	29.00

several previous studies and manufacturers' statements (Columbus Division of Electricity and Ohio State Univ.; Black and Veatch, Inc.; Hecht et al.; National Center for Resource Recovery). To allow for contingencies, the medium and high estimates for capital outlay are derived by increasing the low estimate and the resulting medium estimate by 25%, respectively. The net ferrous revenue estimates are derived primarily from analysis done by Abert et al. at the National Center for Resource Recovery (Abert and Zusman) and from discussions with agency and consulting firm staff members (Sharp, Smith). Generally, the evidence is not sufficient to assign probabilities to the array of possible values for each of the key technical and economic parameters. Variations in all parameters may occur, but the medium parameter estimates are assumed to represent the "most likely outcomes."

The discount rate chosen is recognized to be crucial to the outcome of the analysis. The rate indicates if capital provided for any particular project yields as high an economic return as it would among alternative uses. The choice of a discount rate also involves social value judgments about benefits and costs that may accrue to future generations. To minimize subjective argument concerning the validity of using a particular rate of discount, three rates are utilized in the analysis—5%, 9%, and 11%.

Estimates of Benefits and Costs

The medium estimate for initial capital outlay (K) for the processing facility and the power plant conversion is presented in table 2. A detailed description of the resource recovery prototype and the development of the individ-

Table 2. Orrville Solid Waste Processing and Plant Conversion Capital Cost, Medium Estimate

Equipment or Item	Material ($)	Labor ($)
Scales and scale house	47,500[a]	—
Shredder with infeed conveyor and explosion suppression	262,500[a]	—
Conveyors systems	123,750	47,750
Air classification, fan., ducts and dust collection	118,625	58,750
Secondary shredder and conveyors	170,000[a]	—
Shredded storage bin	150,000	62,500
Ferrous separator (two-stage)	56,250[a]	—
Outfeed and pneumatic transfer systems	318,750[a]	—
Boiler and burner modification	500,000[a]	—
Electrical equipment	275,000[a]	—
Water and sewerage	187,500[a]	—
Buildings	262,500[a]	—
Auxiliary and miscellaneous equipment	180,000[a]	—
Total	2,652,375[a]	169,000
Subtotal, equipment and items		2,821,375
General contracting (23%), engineering (10%), and contingency (12.5%)		1,283,727
Grand total		4,105,101

Sources: Columbus Division of Electricity and the Ohio State University; Black and Veatch, Inc.; Hecht et al.; National Center for Resource Recovery; Sharp; Smith.

[a] Price listed includes labor costs.

Table 3. Estimates of First Year (1975) Direct Benefits and Operating Costs

Description	Firing Ratio 15:85	20:80	25:75
Direct benefits ($)			
Green Township landfill operating costs[a]	158,761	158,761	158,761
Transport costs to Green Township landfill[a]	127,174	127,174	127,174
Coal savings[b]	256,905	342,540	428,175
Ferrous metal net revenues[c]	69,696	92,928	116,160
Total ($)	612,536	721,403	830,270
Operating costs ($)			
Resource recovery plant[d]	238,519	238,519	238,519
Mt. Eaton landfill[e]	75,542	66,305	57,384
Transport of waste to recovery plant[f]	67,822	90,443	113,016
Transport of residual waste to Mt. Eaton landfill[f]	57,229	34,336	10,174
Total ($)	439,112	429,603	419,093

[a] From detailed budgets developed in Luttner.
[b] Based on replacing 45, 60, and 85 tons of coal per day at $17.30 per ton for 330 operating days per year.
[c] Based on recovery of 9.6, 12.8, and 16.0 tons of ferrous per day at $22.00 net revenue for 330 operating days per year.
[d] Based on estimated operating costs under the 20:80 firing ratio (Luttner). More precise estimates of operating costs will be possible as actual data become available at the resource recovery plant in Ames, Iowa, the first facility of this type and size.
[e] Operating costs decrease with increased firing ratios because less waste is landfilled at higher ratios. Detailed budgets presented in Luttner.
[f] Transport costs increase to the recovery plant and decrease to the landfill with increased firing ratios (Luttner).

ual capital outlay line items is presented in Luttner.

Table 3 presents the estimates of first year (1975) primary or direct benefits and operating costs for the solid waste resource recovery prototype under three refuse-to-coal firing ratios. Coal savings are based on actual coal prices paid by Orrville Municipal Power in 1975 ($17.30 per ton), and ferrous metal net (of transport costs) revenues are based on the medium parameter estimate of $22.00 per ton. The direct benefits and operating costs are not discounted, and initial capital outlay (K) is not included in table 3.

The Green Township landfill operating and transport costs represent the least-cost potential landfill alternative for Wayne County determined from a previous analysis (Hitzhusen and Poling). This proposed site is located in north central Wayne County near the midpoint of waste generation. The resource recovery prototype located near the proposed landfill site would eliminate the need for this proposed landfill and its associated operating and transport costs. Thus, these costs or savings are counted as direct benefits. Some landfilling would still be required with the resource recovery prototype for the solid waste generated in excess of the power plant capacity and for the increased fly ash from the plant boilers. An existing landfill at Mt. Eaton in southeast Wayne County is of adequate size and location for this purpose. Thus, the estimated operating and transport costs associated with this landfill are included as costs of the resource recovery prototype for each of three refuse-to-coal firing ratios.

The foregoing first year budgets are projected for a recovery system plant life of twenty years. Inflationary effects are incorporated into the twenty-year projections based on performance data relevant to each major cost or benefit component over the prior twenty-year period. For example, data from the Bureau of Labor Statistics for 1954–74 are utilized to calculate labor cost increases over the life of the project (Council of Economic Advisors). In estimating the benefits and costs in the period in which each is incurred, it is assumed that the discount factor fully compensates for the rate of inflation (Howe, p. 55).

Results of the benefit-cost ratio and net benefit analysis are presented in table 4 for the medium or "most likely outcome" level of initial capital investment estimate (K). Nine future benefit and cost streams are computed for each of the three refuse-to-coal firing ratios. The low, medium, and high economic parameter projections in table 1 and projected operating budgets for the various direct benefit and operating cost components of the resource recovery system are utilized in computing the discounted present values for each of the future benefit and cost streams.

The data in table 4 indicate the relative impacts of changes in the alternative technical

Table 4. *B/C* and B-C Analysis of Resource Recovery Prototype by Firing Ratio and Alternative Parameter Projections, 1975–95, *K* = $4,105,101

Firing Ratio Parameter Projection	Discount Rate 5%		9%		11%	
	B/C	B-C[a]	*B/C*	B-C[a]	*B/C*	B-C[a]
15:85						
Low	1.09	1,194	0.94	−728	0.87	−1,374
Medium	1.29	3,955	1.10	955	1.01	33
High	1.52	7,076	1.27	2,967	1.16	1,541
20:80						
Low	1.32	4,218	1.15	1,472	1.06	498
Medium	1.64	8,568	1.35	3,713	1.24	2,284
High	1.91	12,197	1.59	6,317	1.45	4,383
25:75						
Low	1.60	7,703	1.37	3,778	1.27	2,450
Medium	1.95	12,306	1.64	6,581	1.50	4,682
High	2.34	17,506	1.95	9,837	1.77	7,309

[a] 1,000 dollars.

and economic parameter values upon the *B/C* and benefit-cost economic criteria at the medium estimate for capital outlay (*K*). For example, given medium values for all parameters, increases in the firing ratio from 15:85 to 20:80 and from 20:80 to 25:75 increase net benefits by $2.758 million and $2.868 million, respectively. Examination of the other data permits the determination of the relative effects of the range in values of the individual technical and economic parameters on economic feasibility. The effect of the low and high estimates for capital outlay can be observed by subtracting $821,020 or adding $1,026,275 to the net benefit values in table 4. These values represent the difference between the low and medium and the high and medium estimates, respectively, for capital outlay (*K*).

Sensitivity analysis is done allowing each of the key technical and economic parameters to vary from its low to high value while holding the remaining parameters at their medium values. Under this type of analysis, the ranking of parameters from largest to smallest impact on net benefits is as follows: (*a*) refuse-to-coal firing ratio, (*b*) project estimates for the coal and ferrous metal price parameters,[2] (*c*) rate of discount, and (*d*) initial capital investment.

Analysis of the resource recovery prototype by the medium parameter estimates represents the "most likely outcome." While somewhat arbitrary, the evidence gathered indicates that the medium parameter projections represent the most plausible values. Analysis of the most likely outcome situation with the benefit-cost ratio and net benefit criteria yields the following criteria:[3] benefit-cost ratio = 1.35 and net benefits = $3,713,000.

These data suggest that the prototype is an acceptable use of resources. Its benefit-cost ratio is well in excess of unity, it provides substantial positive net benefits, it recovers the initial investment in slightly over one-half its expected life, and it provides a rate of return equal to or greater than most measures of the opportunity cost of capital in the private sector.

Monetary measures of the indirect benefits of reduced landfill created water pollution and reduced harmful emissions at the power plant were not possible. However, some attempts were made to get physical measures of these effects.[4] For example, three types of emissions from coal-fired power plants are generally recognized as harmful to humans, animals, vegetation, and structures. They are particulate matter, sulfur dioxide (SO_2), and nitrogen oxides (NO_x) (Council on Economic Advisors Priorities).

By substituting prepared refuse for coal at Orrville Municipal Power, it is anticipated that a reduction in emissions of SO_2 will occur due to the low sulfur content of refuse compared with coal. Particulates and NO_x emissions will probably remain unchanged. A 0.1% sulfur level in the combustible refuse, 3.8% sulfur content in the coal, and a 20:80 refuse-to-coal firing ratio result in decreased sulfur emissions equivalent to 786 tons per year at Orrville Municipal Power. This represents an 18% reduction in the 1975 sulfur emission level of 4,161 tons (Luttner).

Even physical measures were difficult to secure in the case of leachate water pollution from the existing landfills in Wayne County. Discussions with the local Soil Conservation Service (SCS) representative suggest that surface water is probably already being polluted by the current landfills and pollution of groundwater aquifers under or near the landfills is a distinct possibility. However, the monitoring done to date by the SCS and the

[2] Additional analysis reveals that, when the coal and ferrous metal price parameters are considered separately, coal maintains a second-place ranking and ferrous prices rank fifth.

[3] Under the same medium parameter estimates, the pay-out period is 10.7 years and the internal rate of return is 17.9%.

[4] The original study presents a detailed discussion of the probable reductions in landfill leachates and power plant emissions from resource recovery (National Center for Resource Recovery, pp. 76–80, 92–105).

City of Wooster Public Works Department is inadequate to develop precise measures of the exact nature and degree of water pollution (Luttner).

Summary and Implications

The results of the analysis suggest that the resource recovery prototype is an economically feasible investment. This conclusion is substantiated by a majority of outcomes based on sensitivity analysis of five key technical and economic parameters examined under alternative benefit-cost and internal rate of return criteria.

The analysis also reveals the impact of the key technical and economic parameters on the economic feasibility of the prototype. These parameters, in order of importance, are: the refuse-to-coal firing ratio, projection estimates for coal prices, rate of discount, initial capital investment, and net ferrous metal prices.

It was not possible to get monetary measures of any potential external effects from implementation of the resource recovery prototype. However, no technological external diseconomies were evident. Any future efforts to attach monetary values to those technological external economies given physical measures in this analysis (reduced landfill leachates and power plant sulfur emissions) will further enhance the economic feasibility of resource recovery from solid waste.

The primary thrust of resource recovery is to provide an economical, environmentally acceptable method of solid waste management. The recovery of energy and material resources is in itself a secondary goal. Such systems are attractive alternatives to traditional costly waste disposal practices because resource (energy and materials) recovery appears to be potentially a break-even or net benefit alternative.

The Orrville case study provides quantitative support to the position that, given certain conditions, nonmetropolitan as well as metropolitan areas may find resource recovery to be an attractive alternative. Prerequisite conditions appear to include the existence of an electric power plant or industrial boiler capable of burning refuse, the ability of the facilities in question to burn enough refuse (e.g., 100 to 200 tons per day) to justify the expenditures required to convert the plant and construct and operate the solid waste processing facility, and a population base large enough to supply an adequate waste volume (e.g., 100 to 200 tons per day). Rising prices of conventional fuels and a lack of landfill space generally increase the desirability of resource recovery but are not prerequisites to its feasibility.

Secondary data indicate the existence of over 300 coal-burning steam-electric generation plants, and data are currently being collected on industrial plant boilers in the nonmetropolitan counties of the United States. Present evidence on the specific characteristics of these plants and their surrounding waste generation areas is inadequate to make any conclusive statements on their technical and economic feasibility for resource recovery. However, it would appear that substantial potential exists. A regional resource recovery research project currently underway at Ohio State University is assessing this potential for the twelve North Central states.

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n in production is studied for the medium-stage developing n. Results suggest that, in a densely populated agriculture where y carried out by small family farms, education of farmers of a t six years of schooling on average) is able to contribute to id development is in progress. Unlike in U.S. agriculture, the er effect surpasses that of allocative and scale effects, suggesting rtance of these effects may vary with farm size and with the average

iciency, education, production function, profit maximization,

s been empirically ver- ctor of production in ne, Huffman, Khaldi, eloping agricultures, t so clear. In a study Brazil, Wharton is meaningful relationship performance and educa- esting that the contribu- an early stage developing tain. As for medium-stage ltures, some positive evi- ned by Tang and by Ho in Japan and Taiwan, respec- tudies, however, the contribu- on of farmers is intermingled gricultural research and exten- portance of the contribution of f farmers alone in a medium-stage g agriculture is still an open ques- e present study is an attempt to pro- n answer.

The empirical setting of the study is the transitional farm economy of Taiwan.[1] The sample contains 310 bookkeeping farms in three years (106 in 1964, 117 in 1965, and 87 in 1966) drawn from three mixed farming regions of the island.[2] Agricultural production in Taiwan is mainly carried out by family farms of small size (about 1.2 hectares per farm in 1965; [Taiwan, Provincial Government of 1967c]). A majority of the farm people are formally educated, about 30% having six or more years of schooling (Taiwan, Provincial Government of 1967a); the sample average of educational attainment of farm operators is 6.7 years. The sampled regions are further characterized by rapid technical progress during the study period.[3] This study addressed itself to

Craig C. Wu is an assistant professor of economics, University of Alabama.

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[1] Modern agricultural development in Taiwan was initiated at the turn of the century. Active extension of new sources of income streams was largely witnessed after 1955. From 1952 to 1967, real agricultural output grew at a rate of about 6% a year (Shen; Taiwan, Council of International Economic Cooperation and Development).

[2] The three regions are the eastern mixed region, the southwestern mixed region, and the banana and pineapple region. (The other five regions are more or less specialized in growing rice, tea, or sugarcane.) The bookkeeping data for the study period were published in averages by the Provincial Government of Taiwan in its annual *Report of Farm Record-Keeping Families in Taiwan* (1965, 1966, 1967b). Data on individual farms used in the study were collected from bookkeeping records in custody of the provincial government. A feature of the study period is the relative stability of prices. According to the *Taiwan Statistical Data Book, 1968* (Taiwan, Council of International Economic Cooperation and Development), general prices of farm products were about 1% lower in 1965 than in 1964 and about 2% higher in 1966 than in 1965; while prices paid by farmers for productive supplies were 0.8% higher in 1965 than in 1964 and 0.3% higher in 1966 than in 1965. In view of the price stability, it seems legitimate to pool the data in the three years together, treating each year-farm as a data unit.

[3] From 1963 to 1966, the unit yield of banana increased by 60%, sweet potatoes, 55%, pineapple, 32%, corn, 29%, soybean, 26%, etc. (Taiwan, Provincial Government of 1967d). These are the crops mainly grown in the sampled regions.

the question of whether farmers' education of a moderate level can contribute to production in small-scale farming in a medium-stage developing agriculture when there is a rapid technical progress.[4]

The approach of the study is similar to recent studies for U.S. agriculture. This approach investigates the effect of education in terms of technical and allocative efficiencies. The contribution of education to technical efficiency is called a worker effect and that to allocative efficiency, an allocative effect (Welch).[5] The worker effect is usually estimated by incorporating an education variable in the production function. It is when the authors examine the allocative effect that they differ in their empirical models.[6] Both Fane and Khaldi concentrate on efficiency in cost minimization. As noted by Khaldi, "the role of education includes, in addition to cost minimization, the opportunity loss incurred from not maximizing profits" (p. 654). Hence, both studies use a limited or partial optimization model that leaves the problem of optimum or profit-maximizing output untackled. Huffman's model is superior in this respect. He adopts a full profit maximization model, but his empirical examination is confined to a single dimension of allocative effect, the utilization of nitrogen fertilizer. In this study, I adopt a full profit maximization model in which the allocative effect is examined with respect to all variable inputs. If one is interested in knowing the magnitud tion's contribution to allocative eff study provides a more complete

There is another possible eff tion, the importance of which been fully recognized. When c positive effect on technical when education is a fixed resc has an impact on the scale variable inputs in the short timum size of the firm in th and House use the variati ficiency among farms to ex in farm size and find a pc tween technical efficienc Huffman also finds such a of the use of nitrogen f effect refers to the scal farm (in terms of varia run or in terms of all m run), it is called the sc This effect is also ex

The Model

The three effects o sented in the context be anticipated output, fixed inputs, X^o a vecto inputs, and E educatio farm operator, where Y^a a in money terms. Assumin the anticipated production written as

$$Y^a = f(Z^o, X^o, E \quad (1)$$

When profit is maximized with ticipated output, the optimu maximizing amount of variable i

$$X^*_j = g^*_j(Z^o, E), \quad (2)$$

and the optimum output is[9]

[4] Rapid technical progress should provide a favorable milieu for education to contribute to production. One may suspect, however, that the significant contribution of education in U.S. agriculture, especially in terms of allocative efficiency, is perhaps due to the complexity of management of large farms. The operation of small farms may leave little room for education to contribute. This is, of course, a question to be answered empirically. Furthermore, in explaining his failure to find a significant effect of education in Brazilian agriculture, Wharton suggests that the "number of years of school completed is an extremely imperfect measure when one is working at the low end of the scale with very few years of schooling completed" (p. 207). Whether the education level in my study area is high enough for me to bypass this difficulty is also something to be decided empirically.

[5] The allocative effect can be decomposed into an effect on optimal use of variable inputs and an effect on optimal allocation of fixed inputs. For lack of data on actual allocation of fixed inputs among competing uses, the allocative effect examined in this study, as in the other studies, is in the former sense.

[6] Only Fane, Huffman, and Khaldi have studied allocative effect. While Miller is primarily concerned with technical efficiency, the empirical part of Welch is a study of total effect. Welch, however, suspects that the worker effect is probably small as compared with the allocative effect (p. 47). This is confirmed for U.S. agriculture by Huffman's estimate of $6.08 for worker effect and $10.40 for allocative effect on the use of nitrogen fertilizer alone. As discussed in note 4, however, the small-scale farming in Taiwan may reduce the relative importance of allocative effect. The importance of allocative effect as compared with worker effect for small farms should also be tested empirically.

[7] Huffman calls this effect a joint worker-allocative (or technical-allocative) effect. His findings show that the dollar value of this effect ($11.20) is about that of the allocative effect ($10.40).

[8] Schultz (p. 164) argues that the adoption of new factors of production depends mainly on profitability. The positive effect of education on technical efficiency normally raises the marginal productivity and, hence, the profitability of new inputs. Therefore, my examination of the scale effect of education with respect to new inputs such as chemical fertilizer may be taken as an indirect test of Schultz's profitability hypothesis.

[9] The word "optimum" is used in this paper to mean "profit maximizing" and a variable with asterisk means the optimum amount of the variable. Likewise, superscript a is used for anticipated amount and superscript o is used for observed amount. Since prices are assumed constant, they do not appear as arguments in equations (2) and (3).

$\ldots Y^* = f^*(Z^o, X^*, E)$.

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$\ldots C^* = \Sigma X^*_j$.

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The second term on the right-hand side of equation (11) implies that, even if E_0 and E_1 are equally allocative-efficient, E_1 can still make a larger π^a because E_1 may have a larger π^* (i.e., $d\pi^*/dE > 0$). To see how E_1 can have a larger π^*, consider equation (8). If the first term on the right-hand side of equation (8), $\partial f^*/\partial E$, is positive, E_1 can produce a larger Y with the same amount of material inputs. This is then the usual definition of technical efficiency or worker effect of education. When $\partial f^*/\partial E$ is positive, E is an argument in equation (2), and E_1 has a larger X^* (i.e., $\partial g^*_j/\partial E > 0$). Accordingly, this term is the scale effect of education.

Substituting equation (8) into equation (11),

$$(12)\quad \frac{d\pi^a}{dE} = \pi^* \frac{du}{dE} + u\frac{\partial f^*}{\partial E} + u\sum\left\{\left(\frac{\partial f^*}{\partial X^*_j} - 1\right)\frac{\partial g^*_j}{\partial E}\right\}.$$

The three terms on the right-hand side of equation (12) successively measure the allocative, the worker, and the scale effect of education. The partial derivatives, $\partial f^*/\partial E$ and $\partial g^*_j/\partial E$, in the last two terms are expressed in terms of optimum quantities. The multiplication of these derivatives by u means that the possible gain from worker and scale effects is a fraction of optimum gain from these effects if u is less than one. In other words, $\partial f^*/\partial E$ is the marginal productivity of E evaluated at optimum quantities of variable inputs (along with given amounts of fixed inputs). The product of u and $\partial f^*/\partial E$ may be interpreted as the actual gain from worker effect, i.e., the marginal product of E evaluated at actual quantities of variable inputs. Likewise, the product of u and $\partial g^*_j/\partial E$ may be interpreted as the actual increase in input j in response to an increase in E. Hence, equation (12) can be operationally expressed as

$$(13)\quad \frac{d\pi^a}{dE} = \pi^* \frac{du}{dE} + \frac{\partial f}{\partial E} + \sum\left\{\left(\frac{\partial f}{\partial X_j} - 1\right)\frac{\partial g_j}{\partial E}\right\},$$

where f and g_j are, respectively, the empirical production function and the empirical factor-demand function for input j, and X_j is the use of input j in accordance with g_j. To test the existence of the effects of education is then to test a positive du/dE, $\partial f/\partial E$, and $\partial g_j/\partial E$.

When the production function is Cobb-Douglas using m fixed inputs and n variable inputs, the anticipated-output function can be written as

$$(14)\quad Q^a = A\left(\prod_i Z_i^{o^{\alpha_i}}\right)\left(\prod_j Q_j^{o^{\beta_j}}\right)\exp[\Psi(E)]$$

for $i = 1, \ldots, m$ and $j = 1, \ldots, n$,

[10] On the assumption that E_0 and E_1 use the same amount of Z^o, which is the basic idea implied in regression analyses, π^* can be the same for E_0 and E_1 if E is not a significant variable in the production function so that it drops out from equation (2), leaving E_0 and E_1 with the same amounts of X^*, C^*, and Y^*.

where Q and Q_j are physical quantities of output and variable input j, respectively, and $\Psi(E)$ is a function of E, the form of which is determined empirically.[11] When output and variable inputs are measured in money terms, the function becomes

$$(15) \quad Y^a = A^\Delta \left(\prod_i {Z_i}^{o^{\alpha_i}}\right)\left(\prod_j {X_j}^{o^{\beta_j}}\right)\exp[\Psi(E)],$$

with

$$(16) \quad A^\Delta = AP\left(\prod_j W_j^{-\beta_j}\right),$$

where P and W_j are prices of output and input j, respectively.

For estimation, the production function for observed output may be specified as

$$(17) \quad Y^o = Y^a \exp(\epsilon),$$

where ϵ is the error term. Once equation (17) is estimated and a statistically better form of $\Psi(E)$ is determined, the test of the worker effect can be conducted by a significance test of the coefficient(s) of $\Psi(E)$.

In order to test the allocative effect by relating u (the allocative efficiency index as defined in equation (9)) to education, π^* and π^a must be estimated. When profit is maximized with respect to anticipated output, the first-order conditions yield

$$(18) \quad Y^* = \left\{A^\Delta \left(\prod_i {Z_i}^{o^{\alpha_i}}\right)\exp[\psi(E)]\right\}^r \left(\prod_j \beta_j^{r_j}\right)$$

and

$$(19) \quad X^*_j = \beta_j Y^*,$$

where $r = (1 - h)^{-1}$, $r_j = \beta_j r$, and $h = \sum_j \beta_j$. From equation (15),

$$(20) \quad A^\Delta\left(\prod_i {Z_i}^{o^{\alpha_i}}\right)\exp[\Psi(E)] \equiv Y^a / \prod_j {X_j}^{o^{\beta_j}}.$$

Substituting equation (20) in equations (18) and (19) yields

$$(21) \quad Y^* = (Y^a)^r \prod_j (\beta_j / X_j^o)^{r_j}$$

and

$$(22) \quad X^*_j = \beta_j (Y^a)^r \prod_j (\beta_j / X_j^o)^{r_j}.$$

It then follows that

$$(23) \quad \pi^* = (1 - h)(Y^a)^r \prod_j (\beta_j / X_j^o)^{r_j}.$$

[11] Four forms of $\Psi(E)$ are specified for empirical fitting, which are given later as equations (40) through (43).

Once the production function is estimated, π^a and π^* can be obtained from equations (6) and (23), using estimated production coefficients. Then, the index u can be calculated by equation (9). To test the allocative effect is to test whether a better educated farmer can bring his u closer to unity. This can be accomplished by relating either u or its squared value to E. If there is a favorable allocative effect, a positive relation between the dependent variable and E should be observed.

Variable u is an overall index of allocative efficiency with respect to all variable inputs. An allocative efficiency index with respect to individual input j can be similarly defined in terms of costs. Since X is measured in money terms, X_j is the cost of input j. The ratio of observed to optimum cost of input j can be taken as an index of allocative efficiency with respect to input j, i.e.,

$$(24) \quad \frac{X_j^o}{X^*_j} = u_j \text{ for } u_j \leqq 1,$$

with X^*_j being estimated from equation (22). When $u_j = 1$, the management of input j is perfect; otherwise, the management is imperfect. The test of the allocative effect with respect to input j can be accomplished by relating the squared value or the absolute value of the logarithm of u_j to E.[12] In the present case, unlike for u, which cannot be greater than one, an inverse relation between the dependent variable and E is expected for a positive allocative effect.

The overall index of allocative efficiency can also be defined in terms of costs as

$$(25) \quad \frac{C^o}{C^*} = u_c \text{ for } u_c \leqq 1.$$

When equation (22) is substituted in equation (5),

$$(26) \quad C^* = h(Y^a)^r \prod_j (\beta_j / X_j^o)^{r_j}.$$

Hence, the test of the overall allocative effect can be alternatively conducted in the way the individual allocative effect is tested. However, while u_c is defined in terms of cost only, u is defined in terms of profit. The estimates of u thus provide a direct means of evaluating the

[12] The dependent variable of the relation can be alternatively defined as $(u_j - 1)^2$ or $|u_j - 1|$ (Khaldi, p. 654). This definition has been used in the empirical fitting and, in general, a poorer result is obtained.

net contribution of overall effect by equation (10).

The optimum demand for input j is given in equation (19). Based on the optimum demand, the empirical demand function for input j may be specified as

$$(27) \quad X_j^o = A'_j \left(\prod_i Z_i^{o\alpha_i'}\right) \exp[\phi_j(E) + v_j],$$

with

$$(28) \quad A'_j = t(P, W),$$

where v_j is an error term, t is a function of P and W, and W is a vector of variable-input prices.[13] The empirical existence of a scale effect with respect to input j can be investigated by a significance test of the coefficient(s) of $\phi_j(E)$.

Taking geometric mean over j on both sides of equation (27), an average demand function for all variable inputs can be derived as

$$(29) \quad \tilde{X}^o = \tilde{A}' \left(\prod_i Z_i^{o\bar{\alpha}_i'}\right) \exp[\bar{\phi}(E) + \bar{v}],$$

where the tilde symbol indicates geometric mean over j and the overbar indicates arithmetic mean over j. Such an average relation can be used to test the "overall" scale effect for all variable inputs. The test of scale effect based on equation (27) or equation (29) only refers to the use of input(s). The net contribution of scale effect should be evaluated in accordance with the last term of equation (13).

Estimation

Production Function and Worker Effect

A preliminary review of the data reveals that total output of the family farms of Taiwan consists mainly of crop output and hog and poultry output (hereafter referred to as poultry output), with crops being the primary line of production (sample average of poultry income is about 15% of crop income). These two lines of production are presumably quite different in nature. Thus, two separate production functions are adopted, the form of which is assumed to be Cobb-Douglas as specified in equation (17).[14] The crop production function includes crop income in New Taiwan dollars (NT$1,000) ($Y_c$) as output;[15] labor in man-days (N_c) and land in NT$1,000 ($L$)[16] as fixed inputs; capital services in NT$1,000 ($K$),[17] fertilizer expenses in NT$1,000 ($F$), and other farming expenses in NT$1,000 ($M$)[18] as variable inputs; and an education variable in years of schooling of the farm operator (E).[19] The poultry production function also has its output measured in NT$1,000 ($Y_p$) and includes in

[13] When input j is employed exactly according to profit-maximizing conditions, $\alpha'_i = r\alpha_i$ and $\phi_j(E) = r\Psi(E)$. If these equalities always hold, there is no need to estimate the demand function insofar as the test of scale effect is concerned because once E is established as a positive factor in the production function, it is a positive factor in the demand function. But, empirically, the farms may not employ input j according to profit-maximizing conditions. In order to see whether there is empirically a scale effect, one must test a positive effect of E in the empirical factor-demand function. By the same token, the better fitted $\phi_j(E)$ function in the factor-demand function need not be of the same form as the better fitted $\Psi(E)$ in the production function.

[14] This assumption is tested for crop production by fitting a Cobb-Douglas function and a constant elasticity of substitution (CES) function of Kmenta's approximate form to data of ninety-three farms whose poultry-crop income ratio is less than 10%. The CES form does not show a significant improvement over the Cobb-Douglas form and, more importantly, more than half of the estimated coefficients of the CES form either are insignificant or carry signs contrary to expectation. CES is thus not a better form than Cobb-Douglas for the data. de Janvry's generalized power production function is also tested and a similar result is obtained.

[15] The foreign exchange rate in the study period was 40 Taiwan dollars for one U.S. dollar.

[16] The land variable includes reported value of farmer-owned land and imputed value of rented land. The officially appraised value of land sold by the government under the land-to-the-tiller program was 2.5 times the value of annual main crops and the maximum land rental was set by the government at 37.5% of main crops (Koo, p. 36). The value of rented land is imputed at 2.5 times (land rental/0.375), which is equivalent to a capitalization of land rental by an interest rate of 15%. Value, instead of area, of land is used for the land variable because the area data do not give a meaningful measure of land input. The reported land area includes paddy land, dry land, and forest land, which are quite different in value productivity.

[17] The capital variable includes 30% (15% for depreciation and 15% for interest cost) of machinery and equipment and 1.075 times expenses on small tools, supplies, and repair, where 0.075 is half of an assumed interest rate of 15% a year.

[18] Other expenses include seed and seedling expenses, farming materials and supplies, pest control expenses, and irrigation expenses. Data on these separate items are available. The reason for aggregating them is that there are too many zero observations when they are treated as separate variables, which are not appropriate for a Cobb-Douglas production function. Also, interest cost is not added to this and other similar variables because a proportionate change of the value of the variable does not affect the estimate of its coefficient.

[19] It is standard procedure to treat land as a fixed input in a short-run model. This is legitimate for the present study because the land-reform regulations of Taiwan restrict transfer of farmland. Labor is also assumed as a fixed input because farm labor is primarily provided by family members. The idea of fixed labor input for family farms is shared by Duloy. Although the number of family members is fixed in the short run, the supply of family labor should depend on the family's utility function. If in the short run the arguments of the utility function such as income-producing resources and tastes remain more or less constant, the supply of family labor also remains more or less constant. Capital is not assumed to be a fixed input because this category mainly includes light equipment and tools. This assumption is nevertheless not of vital importance to the empirical results. In the empirical estimation, capital has been alternatively assumed as a fixed input. This alternative assumption does not substantially alter the conclusion of the findings.

addition to E three inputs: labor in man-days (N_p), inventory of livestock and poultry in NT$1,000 ($I$), and breeding and feed expenses in NT$1,000 ($B$).[20]

In estimating the separate production functions, a problem of data availability is encountered. I have data on total labor input (N), the sum of N_c and N_p, but not on N_c and N_p. The problem is solved by an approximation using Taylor's expansion. The optimal allocation of N between crop and poultry production requires

$$\alpha_c\, Y^*_c/N^*_c = \alpha_p\, Y^*_p/N^*_p, \tag{30}$$

or, equivalently,

$$N^*_p/N^*_c = \rho Y^*_r, \tag{31}$$

where α_c and α_p are production coefficients of N_c and N_p, $\rho = \alpha_p/\alpha_c$, and $Y^*_r = Y^*_p/Y^*_c$, the optimum poultry-crop income ratio.

When equation (31) is solved simultaneously with $N^*_c + N^*_p = N$,

$$N^*_c = (1 + \rho Y^*_r)^{-1}N \tag{32}$$

and

$$N^*_p = \rho Y^*_r(1 + \rho Y^*_r)^{-1}N. \tag{33}$$

Using Taylor's expansion around zero ρ, the log form of equations (32) and (33) becomes

$$\ln N^*_c \doteq \ln N - \rho Y^*_r + 0.5\rho^2 Y^{*2}_r \tag{34}$$

and

$$\ln N^*_p \doteq \ln N + \ln\rho - \rho Y^*_r + 0.5\rho^2 Y^{*2}_r. \tag{35}$$

Before the production functions are estimated, Y^*_r cannot be obtained. The actual poultry-crop income ratio ($Y_r = Y_p/Y_c$) may be used for Y^*_r in equations (34) and (35).[21] If $\ln N_c$ and $\ln N_p$ differ from $\ln N^*_c$ and $\ln N^*_p$ by an error term, ϵ_{c2} and ϵ_{p2}, respectively, then the following approximation of $\ln N_c$ and $\ln N_p$ holds:

$$\ln N_c \doteq \ln N - \rho Y_r + 0.5\rho^2 Y_r^2 + \epsilon_{c2} \tag{36}$$

and

$$\ln N_p \doteq \ln N + \ln\rho + \ln Y_r - \rho Y_r + 0.5\rho^2 Y_r^2 + \epsilon_{p2}. \tag{37}$$

When equations (36) and (37) are substituted in the production functions, the following estimation form in logarithms is obtained

$$y_c = (a_c^\Delta + a_1 Y_r + a_2 Y_r^2) + \alpha_1 n + \alpha_2 l + \beta_1 k + \beta_2 f + \beta_3 m + \Psi_c(E) + \epsilon_c \tag{38}$$

and

$$y_p = (a_p^\Delta + a_1 \ln\rho + a_2 \ln Y_r + a_3 Y_r + a_4 Y_r^2) + \alpha_{p1} n + \alpha_{p2} i + \alpha_{p3} b + \Psi_p(E) + \epsilon_p, \tag{39}$$

where the lower-case letter variables are logarithms of the corresponding capital letter variables, a_c^Δ and a_p^Δ are logarithms of A^Δ defined in equation (16), and $\epsilon_c = \epsilon_{c1} + \alpha_1\epsilon_{c2}$ and $\epsilon_p = \epsilon_{p1} + \alpha_{p1}\epsilon_{p2}$ with ϵ_{c1} and ϵ_{p1} being the error terms of the original production functions.

Since equations (38) and (39) contain all the production coefficients, the estimates of the production functions can be obtained by estimating equations (38) and (39). There is, however, another problem involved in estimating equations (38) and (39). As given in equation (16), A^Δ is a function of prices of output and variable inputs. Prices are assumed to be constant at least within each year-region. For the nine year-regions covered in the sample, eight dummy variables are used for a^Δ to take care of possible price differentials among different year-regions.[22] Finally, four alternative forms of $\Psi(E)$ are adopted, letting the data determine the best fit. They are[23]

$$\Psi(E) = \gamma_1 E, \tag{40}$$

$$\Psi(E) = \gamma_1 \ln E, \tag{41}$$

$$\Psi(E) = \gamma_1 E^{-1}, \tag{42}$$

and

$$\Psi(E) = \gamma_1 E + \gamma_2 E^2. \tag{43}$$

Equations (38) and (39) are estimated by ordinary least squares.[24] The estimates are

[20] Farmland is not assumed to be an input in poultry production because raising hogs and poultry in Taiwan is normally carried out in farm houses and does not compete for land with crop production. No distinction is made between fixed and variable inputs for poultry production, since the allocative and scale effects are not examined on this secondary line of production.

[21] Letting ϵ_{c1} and ϵ_{p1} be error terms in the original production functions and assuming that production errors are not correlated with inputs, $Y_r = Y_p/Y_c = Y^*_p\exp(\epsilon_{p1})/Y^*_c\exp(\epsilon_{c1}) = Y^*_r\exp(\epsilon_{p1} - \epsilon_{c1})$. Hence, to use Y_r for Y^*_r means to ignore $\exp(\epsilon_{p1} - \epsilon_{c1})$.

[22] The dummy variables also capture other differences among year-regions such as weather and topographical variations.

[23] So long as $\gamma_1 > 0$, form (40) gives a positive marginal productivity of education (MPE) that increases at an increasing rate, and form (41) gives a positive MPE that decreases at a decreasing rate. So long as $\gamma_1 < 0$, form (42) gives a positive MPE that first increases as E increases to $0.5|\gamma_1|$ and then decreases as E becomes larger than $0.5|\gamma_1|$. So long as $\gamma_2 > 0$, form (43) either gives an MPE that is positive for all E if $\gamma_1 > 0$ or gives an MPE that changes from negative to positive at $E = 0.5|\gamma_1|/\gamma_2$ if $\gamma_1 < 0$. Therefore, to test a positive worker effect is to find a positive γ_1 in equation (40) or equation (41), a negative γ_1 in equation (42), or a positive γ_2 in equation (43).

[24] Since my model assumes profit maximization with respect to anticipated output, the ordinary least-squares method produces consistent estimates (see de Janvry for a general discussion of

Table 1. Estimates of the Crop Production Function

Variable	Coefficient	With $\Psi(E)$ Given in Equation (40)	(41)	(42)	(43)
N	α_1	0.313	0.310	0.306	0.312
		(8.85)	(8.74)	(8.64)	(8.87)
L	α_2	0.177	0.182	0.184	0.175
		(6.59)	(6.82)	(7.02)	(6.56)
K	β_1	0.032	0.033	0.034	0.034
		(1.94)	(2.00)	(2.09)	(2.06)
F	β_2	0.223	0.223	0.225	0.228
		(8.96)	(8.95)	(9.02)	(9.17)
M	β_3	0.133	0.134	0.135	0.133
		(6.70)	(6.71)	(6.76)	(6.72)
E^{Δ}	γ_1	0.009	0.007	0.159	−0.066
		(0.95)	(0.14)	(0.79)	(1.82)
E^2	γ_2	n.a.	n.a.	n.a.	0.005
					(2.12)
	R^2	0.872	0.872	0.872	0.874

Notes: The estimates are obtained from OLS estimation of equation (38) when only significant dummy variables are included. The estimates for dummy and Y_r variables are not reported for sake of brevity. Figures in parentheses are magnitudes of t-ratios. E^{Δ} equals E in equation (40), $\ln E$ in equation (41), E^{-1} in equation (42), and E in equation (43).

summarized in tables 1 and 2. The coefficients of determination are greater than 0.85 for crop production and greater than 0.90 for poultry production. For a sample size as large as 310, this is a strong indication of good fit. Also, when different forms of $\Psi(E)$ are used, the estimates for other variables remain quite stable. The selection of a statistically better form for $\Psi(E)$ is thus achieved without affecting the estimates of other coefficients.

In all four forms of $\Psi(E)$ except equation (42) for crop production, the estimated coefficients of education carry the expected signs for a favorable worker effect. Equation (43) appears to be a better form for crop production, while equation (40) is better for poultry production. In terms of the better fitted forms, the t-ratio of education coefficient is relatively large (2.12 for γ_2 in crop production and 3.20 for γ_1 in poultry production). The evidence suggests the existence of a favorable worker effect of education in both crop and poultry production in the study area.

For an "average" farm that produces under average conditions and uses material inputs at geometric sample mean values, the worker effect is evaluated on the basis of the better fitted production functions to be NT$357 in crop production and NT$246 in poultry production if the educational attainment of the

consistent estimates obtained by OLS for anticipated-output models).

Table 2. Estimates of the Poultry Production Function

Variable	Coefficient	With $\Psi(E)$ Given in Equation (40)	(41)	(42)	(43)
N	α_{p1}	0.452	0.456	0.460	0.453
		(10.6)	(10.6)	(10.6)	(10.6)
I	α_{p2}	0.085	0.085	0.082	0.084
		(3.84)	(3.78)	(3.65)	(3.77)
B	α_{p3}	0.264	0.266	0.271	0.266
		(10.5)	(10.4)	(10.6)	(10.5)
E^{Δ}	γ_1	0.035	0.157	−0.291	−0.010
		(3.20)	(2.46)	(1.16)	(0.21)
E^2	γ_2	n.a.	n.a.	n.a.	0.003
					(1.00)
	R^2	0.920	0.919	0.918	0.921

Note: The estimates are obtained from OLS estimation of equation (39) when only significant dummy variables are included. See table 1 for other notes.

farm operator is one school year higher than sample average.[25]

Allocative and Scale Effects

Examination of allocative and scale effects is restricted to crop production only.[26] Since land and labor are assumed to be fixed inputs, these effects are studied with respect to capital services (K), fertilizer expenses (F), and other expenses (M).

As outlined before, the estimation of the allocative effect is in general to relate allocative efficiency index to education. The allocative efficiency index is defined either as a ratio of anticipated to maximum profit or as a ratio of observed to profit-maximizing cost. In calculating the anticipated and optimum values, the production coefficients obtained from the better fitted crop production function are used. The relations between allocative efficiency index and education are specified as

$$\theta = d_0 + d_1 E^{-1} \tag{44}$$

or

$$\theta = d_0 + d_1 \ln E, \tag{45}$$

where θ equals $(\ln u_j)^2$ or $|\ln u_j|$ for cost ratios or equals u^2 or u for profit ratio.

The allocative effect is first investigated in terms of cost ratios. The indices of allocative efficiency are calculated by equation (24) for individual inputs or by equation (25) for overall effect. When equations (44) and (45) are fitted, d_1 is expected to be positive in equation (44) or negative in equation (45) for a positive allocative effect. The estimates of d_1 are presented in table 3.

For all the individual inputs, the estimated slope (d_1) carries signs consistent with a positive allocative effect of education. Although the absolute value definition of θ appears better than the squared value definition for K, the t-ratios of d_1 are all less than two. The evidence does not strongly support an allocative effect with respect to K. There is, however, a more clear-cut indication of allocative effect with respect to F. The t-ratios are all greater than two with the absolute value definition of θ in form (44) being the best fit. As for M, the absolute value definition of θ is better than the squared value definition. Under the absolute value definition, the t-ratios are all greater than two. The evidence also suggests a favorable allocative effect with respect to M.[27]

When the overall efficiency index is defined in terms of cost ratio, form (44) appears to be a better fit than equation (45), but the two alternative definitions of θ make no significant difference. The estimated slope coefficient carries expected signs and large t-ratios (ranging

[25] These are equivalent to US$8.93 and US$6.15, respectively. Noting that the average farm size in Taiwan is about 3 acres, the worker effect found is quite substantial as compared with Huffman's finding of $6.08 for U.S. farms with an average size of 55 acres.

The better fitted form of $\Psi(E)$ in crop production implies a change of MPE from negative to positive at $E = 6.36$ (slightly below the sample average of 6.71). A possible explanation can be provided. Suppose that the adoption of new inputs increases with E but that the effective use of them does not begin to improve until a certain minimum level of E is reached. Then, for farms whose E is below that minimum level, the increased use of new inputs intensifies their ineffectiveness in production and, hence, E shows a negative marginal productivity. After that minimum level of E, the effectiveness in using new inputs improves, and E begins to show a positive marginal productivity.

[26] The family farms of Taiwan self-consumed a large portion of poultry output and used a great deal of self-supplied feed. Under these conditions, profit maximization is not an appropriate assumption.

[27] The sample averages of allocative efficiency index for K, F, and M are, respectively, 1.65, 0.47, and 0.45. On the average, the farms overutilized K but underutilized F and M. This study of allocative effect indicates that while the overutilization of K might not be related to education, the situation of underutilization of F and M improved with education.

Table 3. Allocative Effect—Estimates of d_1

Input(s) under Study	Efficiency Index Defined in Terms of	$\theta = (\ln u_j)^2$ or u^2		$\theta = \lvert\ln u_j\rvert$ or u	
		(44)	(45)	(44)	(45)
K	cost	0.772	−0.306	0.657	−0.204
		(0.71)	(1.11)	(1.48)	(1.81)
F	cost	5.418	−1.268	1.324	−0.253
		(2.95)	(2.71)	(2.82)	(2.10)
M	cost	3.850	−0.743	1.594	−0.362
		(1.40)	(1.06)	(2.74)	(2.44)
K, F, M	cost	3.201	−0.659	1.354	−0.277
		(3.70)	(2.97)	(3.69)	(2.95)
K, F, M	profit	−0.290	0.059	−0.197	0.041
		(2.35)	(1.87)	(2.18)	(1.79)

Notes: Estimates are obtained from OLS estimation of equations (44) and (45). Figures in parentheses are magnitudes of t-ratios.

from 2.95 to 3.70). There is a strong indication of overall allocative effect in the study area.

The overall allocative effect is then studied using the profit ratio defined in equation (9). In the present case, as explained earlier, the signs of the slope coefficient (d_1) of relations (44) and (45) expected for a positive allocative effect are opposite to those expected in cost-ratio studies. The estimates of d_1, also reported in table 3, carry expected signs. It appears that u^2 is a slightly better definition of θ than u, and relation (44) gives a better fit than equation (45). Under either definition of θ, the t-ratios are greater than two in equation (44). The result here is similar to, though somewhat weaker than, the conclusions reached for overall allocative effect in terms of cost ratio.[28]

Using equations (10) and (23), the net contribution of the overall allocative effect can be evaluated once the efficiency index (u) is estimated for given levels of education. When the estimates under the u^2 definition of θ in relation (44)—the best fit among the four alternative definitions and forms—are used in this connection, it is calculated that if the educational attainment of the farm operator of an "average" farm is one school year higher than sample average, the net contribution of the overall allocative effect is NT$117.[29] Contrary to Huffman's findings for U.S. agriculture (see note 6), the contribution of allocative effect is smaller than that of worker effect in the study area.

As discussed, the existence of a scale effect depends on a positive derivative of the factor-demand function with respect to education. The empirical demand function is specified in equation (27) for individual input j and in equation (29) as an overall average. In estimating these equations, similar to the estimation of production functions, year-region dummy variables are used for price variables, Taylor's approximation of labor is used for actual labor, and four forms of $\phi(E)$ similar to equations (40) through (43) are fitted. In all these forms of $\phi(E)$, the estimated coefficient of education carries signs consistent with a positive scale effect. While form (41) appears to be a better fit for K, form (43) is better for the others.

Reported in table 4 are the estimates of demand functions with the better fitted form of $\phi(E)$. For the demand for individual inputs, the t-ratio of education coefficient is relatively large for K (2.19) and not very small for F (1.98) and M (1.88). There is at least a weak indication of scale effect of education on utilization of variable inputs. This result becomes more conclusive when the demand function is estimated as an overall average where the t-ratio is as large as 2.96.[30]

Based upon estimates of the better fitted demand functions for individual inputs, the net contribution of the overall scale effect is evaluated according to the last term of equation (13). For an "average" farm, the overall scale effect is calculated at NT$111 if the educational attainment of the farm operator is one school year higher than sample average. The same figure is obtained when the average demand function is used. Similar to Huffman's findings for U.S. agriculture (see note 7), the contribution of scale effect nearly equals that of the allocative effect.

[28] Since the evidence does not show a strong indication of allocative effect with respect to K, perhaps K should better be treated as a fixed input. Under the alternative assumption of fixed K input, the overall allocative efficiency index in terms of profit with respect to the aggregate of F and M gives the following estimates of d_1: −0.326 (2.80) in relation (44) and 0.065 (2.17) in relation (45) for $\theta = u^2$ and −0.218 (2.90) in relation (44) and 0.044 (2.30) in relation (45) for $\theta = u$, where figures in parentheses are magnitudes of t-ratios. The indication here (all t-ratios greater than two) of an allocative effect with respect to F and M in combination is stronger than that with respect to K, F, and M. This is consistent with the findings of the allocative effect with respect to individual inputs. Also, since the profit-ratio study, unlike the cost-ratio study, considers also the revenue side of the problem, this may explain why a weaker conclusion about the overall allocative effect is reached in terms of profit than in terms of cost.

[29] If K is alternatively assumed to be a fixed input, the corresponding overall allocative effect is evaluated at NT$155.

[30] When K is alternatively assumed to be a fixed input, the estimated result gives a weaker conclusion about the scale effect. The t-ratios of education coefficient are 1.57 for F, 1.54 for M, and 2.03 for overall average.

Table 4. Scale Effect—Estimates of Factor-Demand Functions

Variable	Coefficient	K	F	M	Average
N	α'_1	0.721	0.512	0.552	0.598
		(6.57)	(6.80)	(5.90)	(9.18)
L	α'_2	0.332	0.429	0.536	0.435
		(3.81)	(7.27)	(7.51)	(8.54)
E^{Δ}	γ'_1	0.398	−0.936	−1.124	−1.218
		(2.19)	(1.98)	(1.88)	(2.96)
	R^2	0.413	0.566	0.511	0.651

Notes: Estimates are obtained from OLS estimation of equation (27) for demand for individual inputs and equation (29) for the average demand function with significant dummy variables only. Equation (29) is estimated using the geometric mean of K, F, and M as the dependent variable. Estimates for dummy and other variables are not reported for sake of brevity. Figures in parentheses are magnitudes of t-ratios. E^{Δ} equals $\ln E$ for K or equals E^{-1} in the other columns.

Conclusions

For family farms in Taiwan in the mid-1960s, education of the farm operator is a contributor to farm production. Unlike in the United States, the farms are characterized by small size and labor-intensive farming. They nevertheless experienced rapid technical progress during the study period. This study suggests that in a densely populated agriculture where production is typically carried out by small farms, education of farmers of a moderate level (about six years of schooling on the average) is able to contribute to production when rapid development is in progress.

Education contributes to production in several dimensions. This study found a strong indication of worker effect and allocative effect and also an indication of the "overall" scale effect. The profit contributions of these effects per acre are quite substantial. In U.S. agriculture, the allocative effect is more important than worker effect (Huffman). My findings are to the contrary. The contribution of worker effect in crop production is three times as large as the (overall) allocative effect. This suggests that the way by which education contributes to production is quite different for a small-scale, labor-intensive farming than for a large-scale, capital-intensive farming. Another possible explanation is that, with a higher average education for U.S. farmers, they may all possess the basic skills in using modern agricultural inputs, and hence they do not differ to a large extent in technical efficiency. As a result, the worker effect in U.S. agriculture is relatively small. This further suggests that the relative importance of worker effect may decrease with the average level of education.

In theory, when education has a worker effect, it normally raises the marginal productivity and hence the profitability of material inputs. Consequently, a scale effect should exist on the use of variable inputs in the short run or on the size of the farm in the long run. Empirically, the scale effect may not exist because, for example, farmers may all follow the same instructions given by extension workers and thus use the same amount of variable inputs per bundle of fixed inputs. This may also happen if there are certain constraints on the supply of inputs. Although a significant "overall" scale effect was found, the indication of a scale effect with respect to some individual inputs is weak. This shows that, when one studies the scale effect, it should be estimated empirically rather than calculated from the optimum factor-demand function.[31]

The worker effect (or the marginal productivity of education) in crop production was found to change from negative to positive at about 6.4 years of schooling. This may imply that the effective use of certain inputs does not begin to improve until this minimum level of education is reached. If this interpretation is valid, then a minimum level of education is necessary for farmers to learn effective use of modern agricultural inputs. If modern inputs are introduced in a less-developed agriculture without an accompanying increase in education of farmers, it may result in a large degree of ineffective use. The finding that a minimum of about six years of schooling is necessary for learning the effective use of new inputs seems to be consistent with Wharton's failure to find a significant effect of education in Brazilian agriculture where the farmers had very few years of schooling.

There is, on the average, an overutilization of capital input but an underutilization of fertilizer and other modern inputs. While the overutilization of capital input may not be associated with education, the degree of underutilization of fertilizer and other inputs decreases with education. The findings suggest that, if the situation in Taiwan today is not substantially different from that in the study period, to encourage a more intensive use of capital equipment and machinery by the family farms may not be a wise policy. On the other hand, although the farms of Taiwan have used a great amount of fertilizer and other new inputs (Shen), at least in the regions under study, a further increase in the use of these inputs is still profitable. This study further suggests that one way to increase the use of these inputs is to increase the education of farmers, either in terms of formal schooling or in terms of extension education. Needless to say, an elimination of supply constraints or other barriers such as the attitude of risk aversion on the part of the farmers can also increase the use of these inputs.

The total contribution of education is estimated at NT$825, which includes NT$357 for worker effect, NT$117 for overall allocative

[31] Huffman calculated the scale effect or his joint worker-allocative effect from production-function estimates using a formula similar to the last term of equation (12) in which the partial derivative of factor demand with respect to education does not equal zero if education has a worker effect in the production function.

effect, NT$111 for overall scale effect in crop production, and NT$246 for worker effect in poultry production, if the educational attainment of the farm operator of an "average" farm is one school year higher than sample average (about 6.7 years).[32] According to a previous estimate (Wu, p. 93), total costs—including government and private expenditures but not including opportunity costs in foregone income that may not be important in the study period—of one additional year of schooling per student were about NT$2,790 for the seventh year or NT$3,050 for the eighth year. In comparison with the costs of education, the estimated returns to education in terms of farm production are substantial. Since 1968, the government of Taiwan has extended its public education from six to nine years. This might be a profitable move so long as agricultural production is concerned if the economy of Taiwan sustains its pace of development.

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[32] As mentioned earlier, because of lack of data the allocative effect in terms of allocating fixed input (labor) between crop and poultry production was not investigated. Moreover, the (employment) allocative effect on poultry production was not investigated either. Hence, the estimate of the total contribution of education is not all-inclusive.

Attitudes Toward Risk among Peasants: An Econometric Approach

Edgardo Moscardi and Alain de Janvry

Attitudes toward risk among peasants in Puebla, Mexico, are derived from survey data in a model of safety-first behavior. The measurements of behavior toward risk obtained are then explained by a set of socioeconomic and structural variables that characterize peasant households. Knowledge of the determinants of attitudes toward risk is, in turn, useful for the purpose of tailoring technological recommendations to particular categories of peasants.

Key words: Mexico, peasants, risk aversion, technological change.

A number of recent studies have evidenced the importance of risk on decision making by peasants (Dillon and Anderson, Wolgin, Wiens) and farmers (Lin, Dean, and Moore; Boussard and Petit). Attitudes toward risk are major determinants of the rate of diffusion of new technologies among peasants and of the outcome of rural development programs. If they are going to be effective, new technologies and rural development programs need to be tailored to the attitudes toward risk of particular categories of peasants. For this purpose, it is important to identify the specific determinants of behavior toward risk and to quantify their impact on decision making.

This paper starts by examining the extent to which risk may be responsible for discrepancies between peasants' demand for fertilizer without risk and actual demand under risky conditions. For this purpose, risk is introduced in a model of economic decision making as a safety-first rule. According to this rule, an important motivating force of the decision maker in managing the productive resources that he controls and, in particular, in choosing among technological options is the security of generating returns large enough to cover subsistence needs. As recent empirical studies of peasant behavior indicate, safety-first criteria tend to be followed whenever the satisfaction of basic needs may be at risk (Scandizzo and Dillon).

Assuming that the safety-first model holds, the degree of risk aversion manifested by individual peasants can be derived from observed behavior. Given a production technology, the risk associated with production, and market conditions, the observed level of factor use reveals the underlying degree of risk aversion. In this fashion, attitudes toward risk can be measured for relatively large samples of peasants. Explanations for differential degrees of risk aversion among peasants can then be sought by relating the measures of risk aversion obtained to a number of variables that characterize the peasant household, its income-generating opportunities, and its position in the political economy.

This indirect approach to the measurement and explanation of risk aversion is introduced as an alternative to the direct approach developed by von Neumann and Morgenstern. In this direct approach the subject is asked to make decisions in reaction to a large number of randomly arranged hypothetical bets and insurance schemes. This approach has serious difficulties resulting from the fact that the subjects have different degrees of utility or disutility for gambling (the very method used to reveal their preferences) and that the concepts of probability are by no means intuitively obvious (Edwards). In addition, the method is very time consuming to administer (Lin, Dean, and Moore). As a result, the measurements of risk aversion thus obtained have been few, and attempts at relating these mea-

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Edgardo Moscardi is an economist with the International Center for Wheat and Corn, Mexico, and Alain de Janvry is an associate professor of agricultural and resource economics, University of California, Berkeley.

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surements to explanatory variables have been unsuccessful (Halter and Beringer, Officer and Halter) or only partially successful (Scandizzo and Dillon).

The indirect approach used here is easy to handle empirically and thus makes it possible to manipulate large samples of peasants. The results, however, are fully conditional on how well the model specified describes peasant behavior. The validity of the results depends upon careful screening of the observations so that all discrepancies between actual and predicted behavior that are not due to risk in production are accounted for by the model.

Allocative Efficiency under Safety First

Alternative specifications of safety-first rules have been given by Roy, Telser, and Kataoka. Following Kataoka, maximize d subject to $Pr(r \leq d) \leq \alpha$, where d is the subsistence or disaster net income level, r is the random net income, and α is the accepted probability of disaster (presumably low). This last variable is postulated to depend upon a vector S of variables that represent the socioeconomic characteristics of the peasant household: $\alpha = \alpha(S)$. Assuming the mean μ and standard deviation σ of r to be known, a certainty equivalent to the above model can be derived by maximizing the upper bound of the disaster level given by Chebychev's inequality (Pyle and Turnovsky). Then the model becomes

$$(1)\quad \max V(\mu, \sigma) = \mu - K\sigma \text{ for } K = K(S),$$

where K is the marginal rate of substitution between expected net income and risk, i.e., the measure of risk aversion suggested by Magnusson. Like α, K is a function of the peasant household characteristics S.

Assume that the randomness of net income derives from yield uncertainty. Assume also that the relationship between inputs (vector X) and yield (Y) is represented by a generalized power production function (de Janvry 1972a, b)

$$Y = A\prod_i X_i^{f_i(X)} e^{u}.$$

For a given production function, a given coefficient of variation of yield ($\theta = \sigma_Y/\mu_Y$), given factor prices (P_i), and a given product price (P), the preference order (1) can be maximized with respect to the input levels. The resulting first-order conditions are

$$(2)\quad Pf_i \frac{E(Y)}{X_i} = \frac{P_i}{1 - \theta K(S)},$$

where f_i is the elasticity of production of the ith input. In equation (2), the left-hand side is the expected value of the marginal productivity of the ith input. On the right-hand side, the price of the ith input is compounded by a risk factor that is a function of the socioeconomic characteristics of the peasant household.

Assuming that this model correctly specifies the peasant's decision-making process, the value of the risk-aversion parameter K can be deduced from the observed levels of product and inputs by solving equation (2):

$$(3)\quad K(S) = \frac{1}{\theta}\left(1 - \frac{P_i X_i}{Pf_i \mu_Y}\right).$$

Equation (3) provides a measure of risk aversion that can easily be derived for each peasant from knowledge of the production function, the coefficient of variation of yield, product and factor prices, and observed levels of factor use.

Since risk aversion is measured as a residual from the behavioral equation (2), it tends to include other sources of discrepancy between optimum and actual resource allocation such as, for example, imperfect market and agronomic information, restricted availability of financial capital and inputs, and high opportunity cost of family labor. In order for the measured K to be a pure measure of risk aversion, the data have to be carefully screened to eliminate observations where such constraints may be effective.

Measurements of Risk Aversion

The data used are derived from the Puebla Project in Mexico (International Center for Wheat and Corn). In this well-advertised rural development project, a package of technological and institutional practices designed to increase corn yields was developed and disseminated among peasants. The package included technical information about fertilizer doses, time of application, and plant density, plus institutional arrangements to facilitate access to credit and fertilizer.

The agronomic information needed to estimate the production function for this new technological package was obtained from the field experiments of corn fertilization carried out by the project agronomists between 1967

and 1971. The data consist of 1,142 observations from twenty-five trials conducted in one of the production systems of the project known as Deep Soils of the Popocatepetl. Each basic observation consists of information on yield (Y) in kilograms per hectare, nitrogen doses (N) in kilograms per hectare, phosphorus doses (PO) in kilograms per hectare, soil organic matter (M) in percentage, soil phosphorus content (P) in kilograms of P_2O_5 per hectare, and soil pH (PH) in units. Due to the existence of high correlations among the exogenous variables, the parameters of the generalized power production function are estimated using ridge regression (Hoerl and Kennard). The results are $\log Y = 0.98 + 0.34 \log N - 0.01M \log N + 0.04 \log PO - 0\,P \log PO + 0.01 \log M + 0.32 \log P + 1.71 \log PH$; $R^2 = 0.6$, ridge parameter = 0.2. The information about fertilizer levels actually used by farmers, as well as location and socioeconomic characteristics of peasant households, was obtained from a random survey conducted in 1971. From this survey, a sample of farm households was selected in order to meet two requirements that would insure that the decision model postulated applies. These requirements are that the farmers knew about fertilizer, had used it in the past, and cultivated maize as their major agricultural activity and had no effective family labor constraint in the sense that the difference between available family working time and time allocated to off-farm, income-generating activities was greater than the labor requirements to grow corn using the economically optimum level of fertilizers. Forty-five of the fifty-five farm households in the survey were retained on the basis of these criteria.

Since nitrogen is agronomically the most important input for increasing yields in the area and is also the largest component of variable costs, its marginal productivity derived from the farm experiments is used to calculate the risk-aversion parameter K for each farm household. This marginal productivity is measured for the particular soil conditions of each peasant and for a level of phosphorus corresponding, on the expansion path, to the observed doses of nitrogen used.

The derived marginal productivity together with the coefficient of variation of yield and product and factor prices for 1971 provide a value of K for each farm household using equation (3). A sample of the results obtained is shown in table 1. The estimated frequency distribution of K obtained from its cumulative distribution function using Schlaifer's fractile rule is shown in figure 1. The results show a distribution of risk aversion highly skewed toward the risk averters and centered around $K = 1.12$. This value is close to that estimated by Scandizzo and Dillon for a similar population of subsistence peasants in northeast Brazil but following the direct approach of von Neumann and Morgenstern.

Since Kataoka's safety-first rule implies constrained optima for values of risk aversion greater than zero, the marginal rates of return associated with diminishing degrees of risk aversion can be calculated. The results are shown in table 2. Clearly, the net benefit curve becomes practically flat for expenditures above \$600 per hectare and the marginal rate of return drops drastically. If one thinks of net benefits as returns for risk taking and defines a risk premium as the percentage amount that a farmer requires before exposing himself to a variable income, such a premium is very high for an average farmer (K being about 1), thus discouraging nitrogen fertilization rates beyond some 60 kilograms per hectare.

Table 1. Economic Optimum, Farmers' Use of Fertilizer, and Risk-Aversion Measure, Puebla, 1971

Farmer Identification	Economic Optimum		Farmers' Use		Risk Measure
	N	P_2O_5[a]	N	P_2O_5[a]	
	Kilograms/Hectare				
1	191	23	125	15	0.47
2	100	12	0	0	1.90
3	147	20	54	7	0.93
4	150	21	0	0	1.92
5	155	22	30	4	1.30

[a] Adjusted at the expansion path.

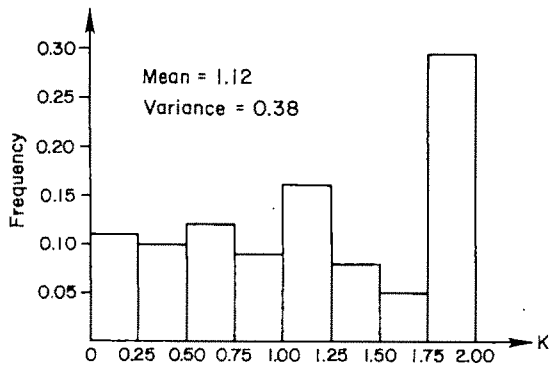


Figure 1. Frequency distribution of the risk-aversion measure *K*

Determinants of Attitudes Toward Risk

Three classes of variables are used to define the socioeconomic characteristics of the peasant households: the nature of the household, its income-generating opportunities, and its access to public institutions. An explanation for the differential degree of risk aversion among peasant households can be sought from these characteristics.

Age and years of schooling of the household head and family size are included in the first class of variables. It is generally assumed that, other factors being the same, older farmers tend to be less prone to take risks than younger ones. This should be particularly true in subsistence agriculture where age can hardly imply greater on-the-job experience (which may be thought to be positively associated with risk bearing), since, on the one hand, the ability to farm under these conditions does not require a lot of experience and, on the other, opportunities to develop informally new types of skills and to use them profitably are not easily available. As table 3 shows, the average age of the household head is quite high: fifty years.

Higher levels of education have generally been associated positively with risk taking. In the area under study, the average number of years of schooling is, however, very low—2.4 years—indicating attendance at elementary school without graduating. Due to this low level of education, the impact of schooling on risk taking can be expected to be positive but not of great importance.

Two opposing interpretations can be given to the relationship between risk taking and family size. One is that, the larger the size of the family, the higher the subsistence consumption needs and, given a fixed amount of land, the lower the willingness of the farmer to assume risks. In this case, family size reflects the consumption needs of children. Another interpretation is that family size reflects the labor capacity of the peasant household. A larger family implies greater availability of labor on the farm, which is particularly important at harvest time when there is a labor shortage in the region and a greater capacity to generate off-farm income. As a result, the capacity of the farmer to assume risks increases with family size. The data support this second interpretation: most family members are actually engaged in productive activities. Average family size is 5.4 members with only 1.5 members below ten years of age.

Table 2. Marginal Rates of Return for Diminishing Degrees of Risk Aversion in Fertilizer Use, Puebla, 1971

Risk-Aversion (K)	Fertilizer Doses		Variable Costs[a]	Net Benefit	Change in Costs	Change in Net Benefits	Marginal Rate of Return (%)
	N	P_2O_5					
	Kilograms/Hectare		U.S. $/Hectare				
0	190	21[b]	1.04	1.83			
					0.22	0.02	7
0.28	150	17	0.82	1.81			
					0.22	0.06	28
0.58	110	12	0.60	1.75			
					0.22	0.13	62
0.94	70	8	0.38	1.62			
					0.22	0.32	142
1.38	30	3	0.16	1.30			
					0.16	0.84	520
1.99	0	0	0	0.46			

[a] Fertilizer, labor, and capital.
[b] Average risk-neutral point.

Table 3. Mean and Standard Deviation of Socioeconomic Variables for Farmers with Different Attitudes Toward Risk, Puebla, 1971

Group	Age	Schooling	Family Size	Off-Farm Income (U.S. $)	Land under Control (Ha.)	Solidarity Group (%)
	----- Years -----					
Total sample (N = 45)						
Mean	50.0	2.4	5.4	123	2.9	30
Standard deviation	15.0	1.9	2.7	288	3.8	
Low risk (N_1 = 6)						
Mean	4.3	3.2	5.0	163	3.9	66
Standard deviation	10.0	2.1	2.8	183	1.9	
Intermediate risk (N_2 = 21)						
Mean	48.0	2.8	6.4	135	2.9	14
Standard deviation	14.0	1.7	2.5	378	3.9	
High risk (N_3 = 18)						
Mean	58.0	1.4	4.9	70	1.8	11
Standard deviation	13.0	1.4	3.2	182	1.6	

The income-generating opportunities of the peasant household are represented by the total amount of land under its control and the level of off-farm income. Total land under control is the amount of land cultivated by the peasant independently of the type of land tenure. According to a benchmark survey conducted in 1967, some 40% of the farmers had a combined private and *ejido* holding, while 30% were pure *ejidatarios* and 40% were pure private small holders. Land tenure differences do not have an impact on economic behavior. The average land under control for the sample under study is 2.9 hectares, including 0.15 hectares under irrigation. The hypothesis here is that having more land under control permits the farmers to bear higher risks. This hypothesis is consistent with both Pratt and Arrow's formulation of decreasing absolute risk aversion for increasing wealth as well as with the recent findings of Wiens regarding peasant risk aversion. Following the logic of safety first, this results from the fact that the risk-aversion constraint becomes less effective as income rises beyond subsistence requirements. In addition, more land makes it possible to spread out risks by cultivating more than one crop or the same crop under different technologies; also, more land often implies different plots at various locations on different kinds of soils and under different climatic conditions.

Off-farm income can be assumed to have an important impact on risk taking. In the sample under study, 65% of the households earned off-farm income, generating some 40% of total family income. This part-time agricultural system is typical of subsistence agriculture in Latin America (Barraclough). The importance of off-farm income as a component of family income increases as farm size is smaller, family size larger, and agronomic conditions more marginal. In the Puebla area, which is fairly urbanized, off-farm earnings are obtained from wages in domestic, commercial, and industrial employment in nearby cities. With rather stable employment opportunities, the hypothesis is that the higher the off-farm income, the higher the capacity of farmers to assume risks in agricultural production.

Only one variable is used to account for the integration of the peasant with public institutions—membership in a "solidarity group." The creation of such groups was induced by the Puebla Project to allow peasants to have access to credit not as individuals but as groups of five to twenty members. In this way transaction costs are reduced for both farmers and banks; technical assistance by the Puebla Project can be provided more effectively; and many farmers who do not have legal title to their land can thus obtain credit as long as at least one member of the group has legal title. Some 30% of the farmers in the sample are members of solidarity groups. What is not known is whether the farmers joined the groups because they wanted to follow the technological recommendations of the Puebla Project or whether they were already using high fertilizer doses but wanted to have easier access to credit. If the latter condition applies, there would be no relationship between risk taking and membership in a solidarity group. If the former applies, as can generally be expected, a farmer in a solidarity group is better able to sustain risks.

A discriminant analysis was conducted to

explore quantitatively the relation between risk aversion and the household characteristics defined above. This multivariate technique is more adequate here than regression analysis for two reasons. First, the interval of variation of K is truncated between 0 and 2 for the behavioral condition (1) to be satisfied with a coefficient of variation of yield of 0.5. Second, it is useful for the design of rural development programs to classify peasants into groups with similar attitudes toward risk and identify the defining socioeconomic characteristics of those groups.

The risk parameter K has been used to classify peasants into three groups: low-risk ($0 < K < 0.4$), intermediate-risk ($0.4 \leq K \leq 1.2$), and high-risk aversion ($1.2 < K < 2$). The general hypothesis that a systematic relationship exists between attitude toward risk and the socioeconomic characteristics of peasant households, as well as the particular hypothesis on each variable discussed above, is rejected or accepted to the extent that the discriminant function estimated assigns the peasant households to the same groups as does the classification variable K. Table 3 shows the mean and standard deviation of the socioeconomic variables for the three groups defined in terms of attitude toward risk. Particularly remarkable is the association between risk taking and off-farm income, land under control, and membership in a solidarity group.

Table 4 makes it possible to compare the classification obtained by discriminant analysis with that established on the basis of risk aversion. Of the total number of observations assigned to each group on the basis of risk aversion, 83% remained in the risk-neutral group, 86% in the low-risk group, and 82% in the high-risk group. No reclassification occurred between the extreme groups. This analysis was repeated on a sample of thirty-one peasant households in another area of the Puebla Project with results essentially similar to those presented here (Moscardi).

For predictive purposes, a regression equation was run between risk aversion and the same socioeconomic variables characterizing peasant households using a combined sample of seventy-six cases from two regions. As can be seen from table 5, the results also support the hypothesis that the risk-bearing capacity of peasants can be explained by their socioeconomic and structural characteristics. Particularly significant for that purpose are the extent of land under control, off-farm income, and membership in a solidarity group.

Conclusions

Estimation of risk aversion for a relatively large sample of farmers, following the indirect method outlined above, shows that risk aversion is indeed responsible for substantial differences between the demand for fertilizer without risk and actual demand. Risk premiums are high, discouraging the use of high rates of fertilizer under safety-first behavior.

Knowledge of the value and distribution of K is important for the construction of models of peasant behavior and of aggregate supply response. Particularly interesting is the fact that, following the much less data-demanding indirect method, results similar to those obtained by direct use of the von Neumann-Morgenstern technique have been obtained.

Beyond random discrepancies, it is possible to establish a systematic relationship between risk aversion and a number of socioeconomic variables that characterize peasant households, their access to income-generating opportunities, and their relation to public institutions. Knowledge of attitude toward risk for particular categories of peasants defined by these socioeconomic variables makes it possi-

Table 4. Households Classified According to Risk Aversion and Discriminant Analysis, Puebla, 1971

	Discriminant Analysis Groups			
Risk-Aversion Groups	1	2	3	Total[a]
1	5	1	0	6
2	0	15	6	21
3	0	2	16	18
Total[b]	5	18	22	45

[a] Assigned by the classification variable K.
[b] Assigned by the estimated discriminant function.

Table 5. Regression Estimates: Risk Aversion versus Socioeconomic and Structural Characteristics

Variables in Logs	Regression Coefficient	t-value
Intercept	2.079950	1.9248
Z_1 = age	0.632502	1.0728
Z_2 = schooling	−0.121252	−0.4496
Z_3 = family size	−0.011686	−0.0424
Z_5 = off-farm income	−0.091616	−2.0901
Z_6 = land under control	−0.477450	−3.0141
Z_7 = solidarity group	−0.365100	−2.3103
	$R^2 = 0.37$	$F = 6.78$

ble, in turn, to determine packages of technological and institutional practices optimally tailored to peasants' economic behavior. Such packages should greatly enhance the chances of success of rural development programs.

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Notes

Price Incentive versus Irrigation Investment to Achieve Food Self-Sufficiency in the Philippines

Yujiro Hayami, Eugene Bennagen, and Randolph Barker

Barker and Hayami, using rice in the Philippines as a case, evaluate product price support and input subsidies as policy alternatives to achieve food self-sufficiency in developing countries. The analysis shows that the input subsidy is more efficient in terms of social benefit-cost criteria when the subsidy is applied to modern inputs, such as fertilizers, that are used below optimum level. However, the self-sufficiency goal can probably be achieved more efficiently in the long run through the improvement in physical and institutional infrastructure for food production.

In this note, the policy comparison includes government investment in irrigation systems so that the social benefits and costs associated with the construction of production infrastructure and the provision of price incentives are compared as alternative policies for achieving food self-sufficiency. As in the previous paper, the analysis is applied to the rice economy in the Philippines.

Methodology and Data

A major problem in comparing price policy with infrastructure development policy is the difference in the distribution of benefits and costs over time. A constant flow of annual government expenditure is required for supporting product prices or subsidizing input prices if a level of output increased by the price incentives is to be maintained. Resulting benefits of producers and savings of foreign exchange also flow in constant streams.

In contrast, if the same amount of output is to be increased by government investments in irrigation systems, a large capital cost (with a certain foreign exchange component) is involved during the construction period. The benefit increases gradually as the major hardware is built and the subsidiary laterals and ditches are constructed. The full benefit emerges when a farming system in the command area is completely adjusted to the irrigation system. The benefit stream can be maintained with a flow of operation and maintenance expenses until the end of a usable life. The government can plow back a part of benefit by charging irrigation fees for the service rendered to farmers in the command area.

In order to compare price policy with irrigation development policy as alternatives to achieve food self-sufficiency, it is necessary to convert their benefits and costs into the same time dimension. The methodology adapted here is to capitalize all benefits and costs associated with an irrigation development project from its initiation to the end of usable life into present values at the time of initiation. Then, using a standard rate of interest, the capitalized values of benefit and cost are converted into infinite annual streams, which are compared with the annual benefit and cost associated with the product price support and the input price subsidy.

Simplifying assumptions for the capitalization of irrigation costs and benefits are the following. (*a*) The whole capital cost is spent in the median year of the construction period. (*b*) No benefit is produced until the construction of the irrigation system is completed. However, the full benefit of the systems in the form of increases in farm output (rice) with corresponding increases in inputs emerges from the next year of completion of government construction project and is maintained until the end of usable life.[1] (*c*) Both the cost of operation and maintenance and the collection of irrigation fee per hectare of command area per year is fixed throughout the period of usable life. (*d*) Government policy is such that an increase in domestic rice output substitutes for an equal reduction in import, thereby resulting in no change in domestic rice supply and prices. An additional amount of fertilizer required to increase domestic output in the expanded area under irrigation is procured from overseas.

The capitalized present values of government costs, farm producers' benefits, and net foreign exchange savings associated with the policy of developing irrigation infrastructure to achieve food self-sufficiency are calculated as follows:

Yujiro Hayami is a professor of economics, Tokyo Metropolitan University, Eugene Bennagen is a research assistant and Randolph Barker is an agricultural economist, International Rice Research Institute.

This study was conducted at the International Rice Research Institute.

[1] Usually the benefit begins to emerge even before the completion of whole construction and increases gradually for a number of years after its completion as farmers adjust their production to the irrigation system. The assumption of a constant benefit stream throughout the usable life of the system may tend to bias the benefit estimate upwards. In order to avoid such a possibility, a conservative estimate of benefit flow is used.

$$\text{Government cost} = \frac{c}{(1+i)^m} + (o - w)\frac{[(1+i)^n - 1]}{i(1+i)^{h+n}},$$

$$\text{Producers' benefit} = (\Delta qp - k\Delta xp_f - \Delta zp_z - w)\frac{[(1+i)^n - 1]}{i(1+i)^{h+n}},$$

and

$$\text{Net foreign exchange saving} = -\frac{e}{(1+i)^m} + (\Delta qp_w - k'\Delta xp_{fw})\frac{[(1+i)^n - 1]}{i(1-i)^{h+n}},$$

where Δq is the increase in rice output required to achieve self-sufficiency (220,000 tons of milled rice), c is the capital cost of building irrigation systems to increase rice output by Δq, e is the foreign exchange component in c, o is the operation and maintenance cost, w is the irrigation fee, Δx is the increase in nitrogen input to produce Δq, Δz is the increase in labor input to produce Δq, p is the domestic producer price of rice, p_w is the import price of rice ($200 per ton of milled rice), p_f is the nitrogen price paid by rice producers ($400 per ton of N), p_{fw} is the import price of nitrogen ($340 per ton of N), p_z is the farm wage rate ($0.85 per man-day), k is the ratio of the total cost of current inputs, capital interest, and depreciation to the cost of nitrogen input for rice production, k' is the ratio of the foreign exchange cost of current inputs, capital interest, and depreciation to the cost of nitrogen input for rice production, h is the period of irrigation construction, m is the median of the construction period, n is the period of usable life of irrigation systems, and i is the interest rate.

The data used are for 1975, so that the benefits and costs of developing irrigation systems are comparable with those of the rice price support and fertilizer subsidy programs estimated in Barker and Hayami.

The specification of data for irrigation costs and benefits depends critically on the type of irrigation system assumed. In this study, a gravity system of the National Irrigation Administration (NIA) is used. However, there is a wide spectrum of technical standards within NIA systems in terms of water supply and control capabilities. On the average, the actual rate of irrigation in the systems command area is low—an estimate shows that actual irrigated areas are only 75% and 33% of total command area, respectively, for wet and dry seasons. Average capital cost per hectare commanded by the NIA systems for which the construction was completed for 1972–75 was 4,600 pesos (Philippines) ($650) at 1975 prices.[2]

However, recent large-scale projects such as the Upper Pampanga River Project (UPRP) have a much higher technical standard at a much higher cost. Such projects have larger foreign exchange components than the traditional small-scale projects. The "UPRP standard," which is used as a yardstick to the future irrigation development plans, assumes that a capital cost per hectare of command area at 1975 prices is 10,000 pesos ($1,430) for flat land and 12,000 pesos ($1,700) for rolling land and that the rates of irrigation in the command area are 100% and 60%, respectively, for wet and dry seasons. The foreign exchange component is assumed to be about one-half of the total capital cost.

The collection of water fees depends on the standard of the system. The NIA rate of water fee is 2 cavans of paddy for wet season and 3 cavans for dry season (1 cavan = 44 kilograms, about 50 pesos per cavan). The collection rate depends on how the command area is irrigated. The UPRP standard system, which has better water control and supply capacity, should be able to collect a larger amount of irrigation fee than the NIA average system.

The operation and maintenance cost per hectare of NIA command area is assumed to range from about 100 to 150 pesos ($15 to $20). The low standard systems tend to be more easily damaged and require frequent repairs. It seems reasonable to assume that the low standard system needs equal or even larger maintenance cost compared with the high standard system if it is to be maintained for the same period of usable life.

Based on the information as summarized above, the two standard systems for NIA irrigation construction are specified (table 1) as "NIA average," which corresponds to the systems for which construction was finished in 1972–75, and "UPRP standard," which corresponds to large-scale projects in NIA future development plan.

Increases in rice output and production costs corresponding to a hectare increase in irrigation systems command area are estimated by assuming that the conversion of a paddy field from rainfed to irrigated conditions accompanies both a shift from traditional varieties to modern high-yielding fertilizer responsive varieties and a shift from a wet-season single cropping to double cropping of rice. Functions estimated by Hayami et al. are used as representing the responses of paddy output to nitrogen:

High-yielding varieties in irrigated fields:

$$Y = 2{,}150 + 18N - 0.08N^2,$$

Traditional varieties in irrigated fields:

$$Y = 1{,}610 + 11N - 0.13N^2,$$

and

Traditional varieties in rainfed fields:

$$Y = 1{,}238 + 8N - 0.1N^2,$$

where Y and N are, respectively, paddy yield and nitrogen input per hectare in kilograms.

It is assumed that the conversion from the rainfed

[2] The official peso/dollar exchange rate in 1975 was about 7 to 1.

Table 1. Data Assumptions Associated with Different Specifications of Irrigation Systems in the Philippines

	Specification	
	NIA Average	UPRP Standard
Averages per hectare of command area		
Capital cost		
Total ($)	650	1,500
Foreign exchange component ($)	260	750
Irrigation rates		
Wet season	0.75	1.0
Dry season	0.33	0.6
Increase in rice output per year (tons of milled rice)	1.5	2.8
Increase in nitrogen input per year (kg.)	60	90
Increase in labor input per year (man-days)	50	80
Operation and maintenance cost per year ($)	20	20
Collection of water fee per year ($)	15	20
Period of usable life (years)	50	50
Construction period (years)	3	5
Total requirements to achieve self-sufficiency		
Increase in command area (1,000 ha.)	147	79
Capital cost		
Total ($ million)	96	118
Foreign exchange component ($ million)	38	59

to the irrigated field accompanied both the shift from the third to the first response function and the increase in nitrogen input from 5 to 60 kilograms per hectare. Resulting increases in rice output (in milled rice terms converted from paddy by a factor of 0.7) and nitrogen input per hectare of crop area for dry and wet seasons are multiplied by irrigation rates and added together to arrive at the estimates of output and input increases per hectare of command area per year. The response function used for irrigated fields corresponds to an average irrigated condition in the Philippines, which is inferior even compared with the NIA average. The yield per hectare assumed for the UPRP standard is 30% to 40% higher than the response function implies. Here, we very conservatively adjust the yield estimates produced from the function upwards by 10% for the UPRP.

The nitrogen cost is assumed to be one-half of the cost of current inputs, capital interest, and depreciation for rice production, of which 80% is supplied from abroad ($k = 2$ and $k' = 1.6$). Further, it is assumed that labor input per hectare of crop area increases from 65 to 90 man-days in the wet season, corresponding to the shift from the rainfed to the irrigated condition, and 0 to 90 man-days corresponding to the one-hectare increase in dry season crop area due to irrigation.

Another critical variable in benefit-cost analysis of irrigation investment is the interest rate, which is assumed to reflect a social discount rate. A standard interest rate for the loans to government-assisted development projects in the Philippines is 12% per year. However, 15% is a commonly used discount rate in the project evaluation by a planning agency (National Economic and Development Authority). In this analysis, we use 12% and 18% as the boundary estimates of the effective rate of interest in development planning.

Policy Comparison

The capitalized present values of benefits and costs associated with government investments in NIA irrigation systems to achieve self-sufficiency in rice in the Philippines are estimated for four different cases (table 2). Case A assumes NIA average standard and 12% interest rate; case B assumes NIA average standard and 18% interest rate; case C assumes UPRP standard and 12% interest rate; and case D assumes UPRP standard and 18% interest rate.

The present value of capital cost for the UPRP standard is about 10% higher than for the NIA average standard, but because the collection of irrigation fee is higher in the UPRP standard, the total government cost is almost the same for both systems. Corresponding benefits for rice producers are about 20% lower for the UPRP standard primarily because of a longer gestation period. The difference in net foreign exchange savings between the two standards of systems is about 20% to 30%, but the difference between different interest-rate assumptions is almost 100%.

The capitalized values of government cost, producers' benefit, and foreign exchange savings for irrigation investment are converted into infinite an-

Table 2. Benefits and Costs Associated with Government Investments in Irrigation Systems for Rice, Philippines, 1975

	Alternative[a]			
	A	B	C	D
	Capitalized Present Value ($ million)			
(1) Capital cost	76	69	84	72
(2) Operation and maintenance cost	17	10	7	4
(3) Irrigation fee	13	8	7	4
(4) Increase in rice output	261	149	208	107
(5) Increase in current input and capital cost	42	24	27	14
(6) Increase in labor input	37	21	25	13
(7) Government cost = (1) + (2) − (3)	80	71	84	72
(8) Producers' benefit = (4) − (5) − (6) − (3)	169	96	149	76
(9) Foreign exchange savings $= -\frac{e}{c}(1) + \frac{p_w}{p}(4) - \frac{k'}{k}\frac{p_{fw}}{p_f}(5)$	333	172	261	123

[a] See text for definitions of alternatives.

nual streams by applying the interests assumed in the capitalization, which are compared with annual benefits and costs associated with rice price support and fertilizer subsidy programs to achieve self-sufficiency (table 3).[3]

In terms of annual flows, the government cost required for the support of rice prices is almost ten times higher than for irrigation development; for the subsidy on fertilizer prices, it is almost five times more expensive. On the other hand, the price support and fertilizer subsidy programs produce larger benefits to rice producers primarily in the form of income transfer from government (taxpayers) to producers.

The calculation of social benefit-cost ratios (assuming the premium on foreign exchange is 5%) shows that irrigation investment is a more efficient means to achieve rice self-sufficiency except for case D, which assumes a higher cost project and a high interest rate. If the social discount rate is high and few possibilities exist for low-cost projects, the fertilizer subsidy program becomes more advantageous to irrigation development project in efficiency criteria.

[3] The fertilizer subsidy program in this comparison corresponds to plan A in Barker and Hayami, in which the subsidy applies only to the rice sector. It was shown that the efficiency of the program can be increased by extending the subsidy to the sugar sector and, at the same time, raising the rate of the sugar export tax (plan C). This plan is not compared here, partly because the plan has never been contemplated actually by policy makers but more importantly because to be compared with plan C a variation of the irrigation development policy should be designed (e.g., to extend the government irrigation investment to the sugar sector and tax away the benefit).

Conclusion

The results in this study show that, despite its large initial capital cost, irrigation investment imposes less financial burden on the government than the manipulation of product and input prices in the long run. In terms of the social benefit-cost ratio, the irrigation development is clearly more efficient than

Table 3. Benefits and Costs Associated with Alternative Policies to Achieve Self-Sufficiency in Rice, Philippines, 1975

	Price Policy		Irrigation Investment[a]			
	Rice Price Support	Fertilizer Subsidy	A	B	C	D
Annual stream ($ million)						
(1) Government cost	106	51	10	13	10	13
(2) Producers' benefit	70	65	20	17	18	14
(3) Foreign exchange savings	62	39	40	31	31	22
Benefit-cost ratio $= \frac{(2) + 0.05(3)}{(1)}$	0.69	1.3	2.2	1.4	2.0	1.2
Internal rate of return (%)	—	—	26	26	20	20

[a] See text for definitions of alternatives.

rice price support. But it becomes inferior to fertilizer subsidy if a high discount rate is applied to a large-scale high-cost project.

In the Philippines, even though the real cost of irrigation construction is rising as the easier sites that can be covered by small-scale low-cost projects are exhausted, areas still exist that can be irrigated by relatively low-cost systems comparable with or even less costly than the NIA average. The average benefit-cost ratio for irrigation development on a scale to achieve self-sufficiency in rice would be close to the NIA average. Considering the high opportunity cost of government funds, the irrigation investment is probably more efficient as a means to achieve rice self-sufficiency in the Philippines in the long run than the use of fertilizer subsidy, even though the conventional benefit-cost ratios are comparable.

However, the social rate of discount for government investment can be higher than assumed in the analysis. The rate of discount for future rice output corresponding to the investment may rise to a very high level in years of rice shortage. In such years, the discount rate for future output conceived by policy makers would become extremely high because it is the rice supply of this year rather than several years later that determines the social stability and, hence, their political position. Therefore, in years of rice shortage, it could become rational for the policy makers to adopt short-run price policies to increase domestic output, despite the long-run inefficiency involved.

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Estimating Agricultural Production by the Use of Satellite Information: An Experiment with Laotian Data

Richard Hooley, Roger Hoffer, and Stanley Morain

Accurate estimates of agricultural output are particularly important in less developed countries (LDC's) because of the large relative size of the agricultural sector. In most LDC's, estimates of national product are hardly useful to the analyst unless the data on agricultural production can be taken as a reasonably accurate measure of the volume of agricultural activity.

Two common ways of measuring value added in agriculture are from the production side and from the income side. The first requires data on agricultural production, intermediate goods used, and, for net value added, an estimate of capital consumption. The second method requires data on income, rents, taxes and subsidies, and estimates of capital consumption. A presumed advantage of estimating agricultural production within the framework of a system of national accounts is that independent estimates of value added are made from both the production and income side. The accounting framework provides an internal check on the consistency of data, since estimates by either method must necessarily be equal.

In fact, however, independent estimates made from both the production and income side are the exception rather than the rule. The United Nations found that only one-third of sixty countries it surveyed have sufficient data on wages and salaries paid in agriculture to make an independent estimate from the income side. The remaining two-thirds make the estimate of output from the production side alone. When classified by income level, the same survey shows that 89% of countries with a gross domestic product per capita of less than $500 rely exclusively on estimates from the production side, compared with only 43% for countries with a gross domestic product per capita of over $1,500 (United Nations 1969). Fiscal systems are not highly developed in LDC's, and taxes on wages and salaries rarely cover the rural population to any significant degree. Moreover, the rural work force is engaged in a variety of occupations, including service, with significant seasonal swings, making it difficult to determine wages and salaries paid for agricultural, as distinct from rural, production. It is precisely in the poorer countries where agriculture contributes in a major way to aggregate output that the dependence on accurate production data is most decisive.

In most cases, agricultural output consists primarily of crop output. The general method of measurement of crop production is well known. It consists of measuring area under cultivation and multiplying the result by an estimate of crop yield, usually obtained by cutting a swath of the standing crop on a sample basis. With proper stratification by geographic area and by type of crop (at least for major crops), this method can produce reasonably accurate results.

Accurate estimates of cultivated area are particularly important in measuring long-run changes in production. This is particularly true in LDC's where farmers often work with traditional technology and expand output along with inputs, including land. The measurement of cultivated area presents serious problems in LDC's because it requires at least one benchmark estimate based on a complete count.[1]

The difficulties of making accurate estimates of cultivated area are of two kinds: problems of establishing an accurate benchmark and those associated with actual measurements of land area. In spite of the efforts of the United Nations, some LDC's still have not taken an agricultural census. For these countries, a benchmark area estimate is still unavailable. For a number of others, training interviewers, reaching areas made inaccessible by topography, and monitoring performance of census interviewers have proved so intractable that the results of the census are of dubious value. Add to this the difficulties of updating such a benchmark periodically, and one can understand why dependable estimates of agricultural land area in use are often difficult to obtain.

A second group of problems concerns area measurements themselves. A number of the poorest

Richard Hooley is with the Graduate School of Public and International Affairs, University of Pittsburgh, Roger Hoffer is with the Laboratory for Applications of Remote Sensing, Purdue University, and Stanley Morain is with the Technology Application Center, University of New Mexico.

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[1] It is possible to utilize sampling procedures to estimate year-to-year variation in area planted, but this information is obviously of little use if there is no benchmark estimate on which to construct an initial estimate of total cultivated area.

LDC's still do not have well-functioning land title systems. In these cases, there is no record of farm size. Consequently, any attempts at a census are bound to be based on what the farmer or census enumerator "guesses" the area of a particular farm to be.

In view of the serious—in many cases overwhelming—difficulties involved in measuring crop production in less developed countries, the possibility of measuring cultivated area by the use of satellite imagery should be seriously considered (Cheosakul, Food and Agricultural Organization, Frey, Heydt and McNair, Park, United Nations 1972). The use of satellite data for estimating production of specific crops has been successfully tried in some developed countries (Baumgardner and Henderson, Morain and Williams, Wigton and Von Steen), but we are unaware of similar works of a comprehensive nature in LDC's, where the potential contribution of the new techniques appears even more promising.

Satellite imagery has been obtained for most of the earth's surface through the LANDSAT-1 and LANDSAT-2 satellites launched in 1972 and 1975, respectively. These data are available to anyone at a nominal cost. The imagery usually utilized is a very small scale—1:1,000,000. Two wavelength bands in the visible (green and red) and two wavelengths in the reflective infrared portion of the spectrum are available. These can be color coded and combined to produce a "color-infrared" composite on which the vegetation appears as tones of red or pink and water features appear in tones of black and blue, thereby facilitating the interpretation. Each frame of data is identified according to latitude and longitude, facilitating the location of areas of interest. Because each frame covers an area of 10,000 square kilometers, these data offer an efficient and economical method of obtaining reasonably up-to-date imagery showing land use patterns in a manner never before possible.

To investigate the feasibility of utilizing such satellite data for the measurement of crop area, we experimented with the available data for Laos, a country of 256,000 square kilometers, approximately two-thirds the land area of Japan. Although the techniques utilized in this case were not very sophisticated (as compared with the techniques currently available), valuable insights into the capabilities and limitations of such an approach were obtained. The lack of "ground truth" data was a particular challenge in this investigation. The procedures and methods followed and the results obtained and costs incurred in satellite data are reported. The results of this survey using only the satellite data are compared with results obtained from ground surveys. Some suggestions are included concerning how the method used in this study can be combined with existing methods now in use to produce more accurate information, much faster, and at far less cost for other developing nations.

Application of Satellite Sensing Techniques to Laos

We began the interpretation with a general understanding of agricultural practices in the region and a good knowledge of the way in which different earth surface features and cover types would appear on Landsat imagery. The best available images were obtained, and the dates of these images were in general accord with the crop calendar for rice as we perceived it. While conditions in Laos were not optimum for a test of satellite interpretative techniques, they were adequate for a general evaluation of the utility of these data.

A complete set of satellite images for the study area was obtained from the U.S. Department of Interior, the distributing agency for Landsat imagery. In all, 187 images of Laos were recorded by satellite between October 1972 and May 1973. Imagery varied in degree of cloud cover and general quality. Hence, of the original 187, approximately 40 images were ordered and processed into diazochrome transparencies.[2] From this latter group, a final selection of twenty-four transparencies was made on the basis of quality and concordance with crop calendars. We were fortunate in obtaining images of a number of agricultural areas on more than one date, which gives a somewhat better basis for interpretation. The image frames were then fitted into a 1:1,000,000 scale transparent overlay map of Laos. By this process, the portion of each image that fell within the national boundaries was defined. In other words, the portion of each image frame to be interpreted was delineated both on overlays of the individual frames and on the overlay of the national map. By this procedure, thirty-eight data measurement areas were delineated on seventeen Landsat images.[3]

A fundamental need for reliable image interpretation is reference data that can be utilized in conjunction with the process of interpretation. In this case, we had nothing to work with aside from our general personal experience in the area. In this first phase of the work, we therefore proceeded without specific reference data but with a general knowledge of the tonal appearance of rice and cropland, as gathered from previous work in Thailand and in the upper Mekong River Basin.

In general, four tonal colors of agricultural land (representing four spectral categories) were visually recognizable on the diazochrome composites. We interpreted each of these tones to be indicative of different types of agricultural land: (*a*) dark-toned

[2] The diazochrome process enables three individual spectral bands obtained in the form of black and white transparencies to be color coded. The color-coded images are then overlaid to form a false color composite. In this form, reflective properties of ground areas can be determined from variation in colors. A map of Laos indicating Landsat image overlays is available upon request from the authors.

[3] Of the twenty-four image frames used for interpretation, seven were obtained over the same areas but on different dates from those required for the Laos mosaic.

to black areas—interpreted as flooded riceland; (*b*) white or nearly white, highly reflective areas—indicative of bare soil or stubble; (*c*) light-toned red or pink areas—when occurring in lowlands may indicate areas cultivated to rice and/or other crops; and (*d*) medium-toned red areas—when occurring in lowlands may indicate orchards; when in uplands indicate forests and other lush vegetation but not grain or vegetable crops.

It is at this point that data from supporting ground observations become critical to the precision of the results. We are reasonably confident after reviewing the imagery and on the basis of on-site field experience that our interpretation of tones (*a*) and (*d*) is correct; that is, dark-toned areas indicate flooded riceland and medium-toned red areas indicate forest or similar lush vegetation. It is much less certain, however, how much of the area in tones (*b*) and (*c*) is correctly interpreted. Highly reflective surfaces, as in tone (*b*), could be indicative of either crop stubble or patches of bare, possibly laterite soil. Light-toned areas, as in tone (*c*), may indicate rice (or other crops) in nonflooded cultivated areas. In some cases rice is difficult to distinguish from nonlush vegetation such as dry, tall grass.

The initial interpretative effort consisted in having two experienced interpreters make completely independent estimates of cultivated areas from the twenty-four data frames described earlier.[4] Both interpreters used the same technique, but since they were working independently in this phase of the study, each used a different definition of cultivated land. The first used a definition encompassing tone categories (*a*) and (*b*) and those portions of tones (*c*) and (*d*) that fell in lowland areas. The second interpreter defined cultivated area conservatively to include only tones (*a*) and (*b*). As a result, two different estimates of cultivated area were obtained: a "conservative" estimate of 743,000 hectares and a broader estimate based on a "liberal" definition of 3,673,000 hectares. The divergence between these two estimates indicated a need to refine our concept of cultivated area by focusing more intensively on regional topographical features.

The second phase of analysis began with a comparison of these independent estimates. As province totals were compared, it became evident that differences between the estimates were highly sensitive to treatment of the light red and pink tones included in tone category (*c*). It became increasingly clear, as preliminary results were compared, that the inclusion or exclusion of tone (*c*) was much more critical in lowland than in upland areas. With this in mind, a second interpretation of the imagery was made, adopting the following definitions for use by both interpreters. Minimum lowland cultivated area is lowland area that was either flooded at the time the image was obtained or was interpreted as stubble. This represents essentially tonal categories (*a*) and (*b*), as earlier defined. Minimum upland cultivated area is all valley bottom land in mountainous areas displaying tone categories (*a*), (*b*), and (*c*). In short, wherever the tone was not bright red (i.e., in the forest) the land was defined as cultivated. This definition works here but not in lowland areas. Laterite and similar terrain are easily confused with tone (*b*). Potential lowland cultivable area is all lowland (valley land) in tonal categories (*a*) through (*d*). This definition includes some lowland that may not have been cultivable because of absence of water or other qualities.

Our estimate of "minimum cultivated area" for the country would, therefore, consist of the sum of the first two definitions. It was necessary to adjust the definition of tonal categories included within the various crop areas when considering upland and lowland area. In general, the lowland areas are characterized by large areas of laterite and other highly reflective soils. These are also areas that support sparse vegetation that can sometimes be mistaken for crops in their early stages of growth. In upland areas, however, exposed laterite soils occur so rarely that any break in forest cover can safely be assumed to be under cultivation.

In reviewing various estimates of crop area, the need for regional crop calendars becomes clear because Laos spans some rather different climatic regimes, particularly when both lowland and upland crops are considered. Furthermore, there seems to be a fair degree of flexibility in planting and harvesting times for some individual crops. Under these conditions, it becomes difficult to use the same image dates for the whole country. Interpretation of the imagery is facilitated if the appropriate dates for imagery are identified in each area based on specific dates for flooding, planting, and harvesting.

Results

With the above considerations in mind, revised estimates of cultivated area were prepared. For reasons explained earlier, an estimate of minimum cultivated area is the most useful. In addition, an estimate of the maximum cultivable lowlands was prepared.

The estimates of minimum cultivated cropland in table 1 represent the best estimates possible at this time utilizing 1:1,000,000 scale Landsat data and unaided visual interpretation techniques; that is, our estimates are conservative approximations of cultivated agricultural area. We relied heavily on identifying tonal groups (*a*) and (*b*). Pink tones (*c*), which were probably areas of at least some crop production, were excluded altogether, since cultivation on small-sized plots was undoubtedly excluded due to satellite resolution constraints.

[4] The estimates were independent both in the sense that each interpreter worked without knowledge of the other's results and also without having ever seen estimates of cultivated area produced from other (nonsatellite) data sources.

Table 1. Cultivable Area Estimated from Landsat Imagery and from Ground Reports, Selected Provinces, 1973

	Landsat: Minimum Cultivated Area (1,000 Ha.)	Ground Survey: Cultivated Riceland (1,000 Ha.)	Landsat as Percentage Ground
Flood plain provinces			
Vientiane	54	52	
Xiang Khoung	28	59	
Borikhane	16	13	
Kahmmouane	59	70	
Savannakheet	141	151	
Wapik Kanthong	37		
Champassak	36	122	113
Sithandone	24		
Sedone	25		
Saravane	32	27	
Subtotal	452	485	93
Mountain/valley provinces			
Luang Prabang	20	38	
Houa Khong	19	27	
Phong Saly	6	15	
Subtotal	45	80	56
Totals for flood plain and mountain/valley provinces	497	565	88
Provinces with poor imagery			
Sayaboury (some images missing)	8	15	
Haua Phouang (cloud covered)	1	25	
Attoupeu (poor quality images)	1	45	
Subtotal	10	85	12
Grand total, all provinces	507	650	78

Source: Commission General of the Plan.

In several areas the diazochromes were of low quality. The imagery over Hua Phong contained too much cloud cover to yield good results. That over Attopeu contained defects in printing and, in addition, was a poor selection in terms of the agricultural calendar; one frame over Sayaboury was unavailable. While significant for the provincial totals, these defects and omissions have little effect on the estimate of the national total because none of these three provinces is a major agricultural producer.

It is not entirely clear how close the satellite-derived estimate should actually be to the existing ground estimates. We estimate minimum cultivated area and not "most probable" area. We set out to measure all cultivated cropland, while existing estimates measure only riceland. However, at least in provinces lying along the Mekong River, and to a somewhat lesser extent in mountain provinces, most cropland is in fact planted to rice, so that the two estimates should be comparable.

Our estimates are compared with those taken by ground sampling methods in table 1. The total minimum estimate for the entire country is 507,000 hectares when measured by satellite, as compared with 650,000 as reported by ground methods. However, when the three provinces having poor quality or missing data are omitted, the total for the thirteen remaining provinces as determined by satellite becomes 497,000 hectares. This compares with 565,000 hectares for ground estimates, or a difference of only approximately 12%.

In the flood plain provinces our estimates are close to or above existing ground estimates. For most of the flood plain provinces, the difference is 7% or less between ground estimates and those made by satellite. In the mountain provinces, however, our estimates consistently fall short of ground estimates by a considerable margin. One reason for this is that the Landsat images available and the method of interpretation undoubtedly cause small areas of cultivated land located on the mountainsides to be overlooked. Nevertheless, the differences are substantial. During the period covered by these estimates (1972–73), there was a considerable movement of refugees into and out of the mountain provinces. Provincial ground-based estimates may be more subject to error than is commonly supposed.

These results demonstrate the usefulness of Landsat imagery as a source of data for estimating cultivated area. We emphasize the words "a source" because we do not at this time or in the near future foresee satellite sensory techniques replacing existing ground sampling methods. Rather, remote sensor imagery (and digital data) is a valuable supplement to the existing, but sometimes fragmentary, information available to agricultural economists from ground surveys.

Two impressive features of remotely sensed data

are its relatively rapid availability and low cost. With an earth resources satellite passing over an area every eighteen days, even with delays in gathering, recording, and processing transparencies, data can be available to analysts within a few months. With ground sampling techniques and reporting systems in use of many LDC's, time lags between sample design and the first draft of estimates often amount to a year or longer.

Satellite techniques also contain a distinct attraction from a cost standpoint. The estimates prepared for this report represent an average cost of 0.6¢ per hectare of area estimated. This figure includes start-up costs involved in developing appropriate definitions and in delineating the measurement areas that would not be present in an ongoing project. In an operational project, start-up costs would not be present, although there would be additional costs involved in obtaining ground truth. Over the longer term, therefore, we anticipate the presence of overall economies of size that would make possible an estimate of substantially improved accuracy than that presented here at an average cost per hectare probably below that shown here.

Concluding Remarks

Developing countries need information on the level and composition of agricultural production. Existing methods of measuring the level of agricultural activity leave much to be desired when applied to LDC's. The use of satellite data can make an important contribution to the speed with which data on area under cultivation are available, to improved cost effectiveness, and hence to a shortening of the length of the reporting period. Relatively simple, manual interpretation techniques can be utilized to provide many LDC's with methods that are relatively cheap and that do not require the availability of very highly specialized computer processing capabilities. Where possible more detailed analysis of selected areas is recommended using a stratified, multilevel sampling approach involving aircraft and ground data obtained at the same time as satellite data for specified areas. Efforts to improve methods of interpretation should be focused on a regional basis with the object of developing estimates of area under cultivation separately for each region, making possible more accurate, useful, and more cost-effective results.

There is a need for much more detailed information on crop calendars by region. Cloud-free imagery should be obtained that is coincident with critical dates by crop and by region. There is also a critical need for additional ground truth, especially with respect to the characteristics of vegetation suggested by tone category (c) in both lowland and mountainous regions. When additional ground truth is obtained, consideration should be given to employing of computer-aided analysis techniques for improved accuracy in acreage estimates.

Finally, satellite data may not always present an advance over traditional methods of measurement. It seems reasonable that in many countries the best results will be achieved by an integration of old methods of measurement along with those suggested here. Measurements that can be made effectively by satellite should release skilled manpower, which then can be reallocated to measurement tasks in which its marginal productivity is higher.

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A Note on the Measurement of Technological Progress and Experience in Production

Yakov Amihud

A general way to represent "technological progress" in a single product production function is $Y = F(X_1, X_2, \ldots, X_k, T)$, where Y is output, F is the production function, X_i $(i = 1, \ldots, k)$ are the input factors, and T is a "vector of parameters, each value of which corresponds to a different level of technology. It is natural to think of T as changing in time . . . as knowledge accumulates; in this case, F should be a nondecreasing function of T" (Solow, p. 28).

In many empirical studies, T is represented by time, implying that experience, learning, and knowledge are a function of time and directly induce technological progress, which then leads to an increase in output for any given set of inputs. A frequently used model is $Y = F(X_1, \ldots, X_k)e^{bt}$. In particular, researchers often use the Cobb-Douglas (C-D) production function (see, e.g., Eisner, Evans, Bridge, Barkai and Levhari):

$$Y = A \prod_{i=1}^{k} X_i^{a_i} \cdot e^{bt},$$

where A, a_i $(i = 1, \ldots, k)$, and b are constants, and t is an increasing arithmetic series (e.g., 1, 2, 3, . . .). Then, when researchers estimate the constants and find b to be positive, they conclude that time has a positive effect on production through technological progress, increased experience, and efficiency. This interpretation was made regardless of whether the data are from time-series or from cross-section observations.[1]

The purpose of this note is to suggest that the conclusions of such studies should be regarded with caution, since they do not necessarily follow from the statistical results. The fact that b is significantly greater than zero may have nothing to do with experience. It may result from the fact that the factors' elasticities (a_i) are not constants but random variables, and the quantities of those factors generally increase in time. (Alternatively, it maybe that there is an experience effect, but it is confounded.) A possible caveat in the reported studies is the assumption that the form of the relationship between Y and X is unchanged, i.e., that the production function is constant either through time or across the various producing entities. This assumption is relaxed and replaced by a less restrictive one: the relationship between Y and X may change randomly from one observation point to another, but the expected relation remains unchanged; that is, the distribution of the a_i's is stationary (the moments are constant) throughout the analyzed sample.

The factors' elasticities may vary from one observation point to another in a manner that may be considered by the observer as purely random. As pointed out by Nerlove, in estimation of a cross-section C-D production function with observations taken from various firms' production data, the exponential parameters may be considered random variables that differ from one firm to another.[2] Evans (pp. 250–51) suggests that in estimating the C-D function from time series, the values of the exponential coefficients fluctuate due to the differences in capacity utilization in every period. Sidhu finds that the exponential coefficients (the factors' elasticities) fluctuate through time due to changes in methods of production.

Assuming the distribution of the elasticities in a Cobb-Douglas production function is a truncated normal probability density function,[3] where $E(a_i) = \bar{a}_i$, output can be expressed as approximately a multivariate normal random variable with the following expected value:

$$(1)\quad E(Y_t) = E\left[A \prod_{i=1}^{k} X_{it}^{a_i}\right] = E[\exp(\ln A + \sum_{i=1}^{k} a_i \ln X_{it})]$$

$$= \exp\left[\ln A + \sum_{i=1}^{k} \bar{a}_i \ln X_{it}\right.$$

Yakov Amihud is on the Faculty of Management, Tel-Aviv University, Israel.

[1] For example, Eisner concludes that "there is an upward movement of output of some 2% to 5% per annum not explained by the utilization, capital and employment variables" (p. 451). Barkai and Levhari claim to have found in their study that experience has contributed significantly to the growth of productivity in kibbutz farming (p. 63). Eisner uses time-series and Barkai and Levhari use cross-section data.

[2] Ulveling and Fletcher, observing these differences in the value of the elasticities across firms, attribute it to differences in managerial ability.

[3] A somewhat different approximation, which maintains the results of this note, can be obtained by a Taylor expansion of $E(Y)$ about $\bar{a}_i$ (all i) and truncating it after the second derivative on the assumption that the series converges fast or that the distribution of the a_i's can be well approximated by their first two moments (e.g., that the variance of a_i is sufficiently small relative to its expected value).

$$+ \tfrac{1}{2}\sum_{i}^{k}\sum_{j}^{k} E[(a_i - \bar{a}_i)(a_j - \bar{a}_j)]\ln X_{it}\ln X_{jt}\Big]$$

$$= A\prod_{i=1}^{k} X_{it}^{\bar{a}_i}\exp\Big\{\tfrac{1}{2}\sum_{i}^{k}\sum_{j}^{k} E[(a_i - \bar{a}_i)(a_j - \bar{a}_j)]\ln X_{it}\ln X_{jt}\Big\}.$$

Assume that the quantity of the production factors is increasing in time and that older producing entities (e.g., the firm, the industry, the national economy) are generally larger than the younger ones. This is generally true when estimation is based on time series of a single producing entity that undergoes a certain process of growth. The assumption applies in many cases to cross-section data as well, where the greater the age of the producing entity, the greater its level of labor, capital, and maybe other major factors.[4] Then $X_{it} = f(X_{i0}, T_t, z_i)$, where $f(\cdot)$ is an increasing function of T_t,[5] the age of the producing entity, or merely a time index at period t, X_{i0} is the initial quantity of factor i, and z_i is its growth parameter. Equation (1) above may be rewritten as

$$(2)\quad E(Y_t) = A\prod_{i=1}^{k} X_{it}^{\bar{a}_i}\exp\{g[f(X_{i0}, T_t, z_i), E((a_i - \bar{a}_i)(a_j - \bar{a}_j))]\},$$

and then the only variable in $g(\cdot)$ is T_t, which increases every period t. If $E((a_i - \bar{a}_i)(a_j - \bar{a}_j)) \geq 0$ for $i \neq j$ (for all $i, j = 1, \ldots, k$), then $g(\cdot)$ is an increasing function of T, while if the above inequality is reversed and applies strictly, the sign of $\frac{\partial g(\cdot)}{\partial T}$ is not unambiguously defined. In addition, the OLS estimate of A is biased, while that of the elasticities is unbiased but inefficient.[6]

Sometimes it is argued that technological progress is increasing at a decreasing rate, i.e., that time has a decreasing positive marginal productivity. For example, Barkai and Levhari suggest a model

$$Y = A\prod_{i=1}^{3} X_i^{a_i}e^{b_1T+b_2T^2},$$

where $b_1 > 0$, $b_2 < 0$, and the other variables are as before. This implies that, for these values of b_1 and b_2, $\frac{\partial Y}{\partial T} > 0$ and $\frac{\partial^2 Y}{\partial T^2} < 0$. They find that b_1 is significantly greater than zero and b_2 is negative in all the periods they study, although hardly significantly different than zero.

For some growth patterns of the production factors and for some values of their initial quantities, growth rates, and the moments of the joint distribution of their elasticities, it is possible to obtain $b_1 > 0$ and $b_2 < 0$, even if experience has no effect on output. To illustrate, consider the case of two factors, X_1 and X_2 (labor and capital). Then, by equation (1),

$$(3)\quad E(Y_t) = AX_{1t}^{\bar{a}_1}X_{2t}^{\bar{a}_2}\exp\{\tfrac{1}{2}[\sigma_1^2(\ln X_{1t})^2 + \sigma_2^2(\ln X_{2t})^2 + 2\mathrm{cov}(a_1, a_2)\ln X_{1t}\ln X_{2t}]\},$$

where $\sigma_i^2 = E(a_i - \bar{a}_i)^2$ and $\mathrm{cov}(a_i, a_j) = E[(a_i - \bar{a}_i)(a_j - \bar{a}_j)]$. Assume further that

$$(4)\qquad X_{it} = X_{i0}\exp(z_iT_t^{\frac{1}{2}}),$$

so that $\ln X_{it} = \ln X_{i0} + z_iT_t^{\frac{1}{2}}$, which is an ordinary growth formulation, and the square root of T implies that the rate of growth is declining for older producing entities. Then, applying equation (4) to equations (2) and (3) gives

$$\begin{aligned} E(Y_t) &= E\{AX_{1t}^{a_1}X_{2t}^{a_2}\} \\ &= E\{A[X_{10}\exp(z_1T_t^{\frac{1}{2}})]^{a_1}[X_{20}\exp(z_2T_t^{\frac{1}{2}})]^{a_2}\} \\ &= AX_{1t}^{\bar{a}_1}X_{2t}^{\bar{a}_2}C_1\exp(C_2T_t + C_3T_t^{\frac{1}{2}}), \end{aligned}$$

where C_1, C_2 and C_3 are constant and take the following values: $C_1 = \exp[\frac{1}{2}\sigma_1^2(\ln X_{10})^2 + \frac{1}{2}\sigma_2^2(\ln X_{20})^2 + \mathrm{cov}(a_1, a_2)\ln X_{10}\ln X_{20}]$, $C_2 = \frac{1}{2}\sigma_1^2z_1^2 + \frac{1}{2}\sigma_2^2z_2^2 + \mathrm{cov}(a_1, a_2)z_1z_2$, and $C_3 = \ln X_{10}z_1\sigma_1^2 + \ln X_{20}z_2\sigma_2^2 + \mathrm{cov}(a_1, a_2)(\ln X_{10}z_2 + \ln X_{20}z_1)$. When $\mathrm{cov}(a_1, a_2) \geq 0$, then $C_1 > 0$, $C_2 > 0$, and $C_3 > 0$, and

$$\frac{\partial E(Y_t)}{\partial T_t} = C_2 + \tfrac{1}{2}C_3T_t^{-\frac{1}{2}}E(Y_t) > 0,$$

but

$$\frac{\partial^2 E(Y_t)}{\partial T_t^2} = [(C_2 + \tfrac{1}{2}C_3T_t^{-\frac{1}{2}})^2 - \tfrac{1}{4}C_3T_t^{-1.5}]E(Y_t),$$

whose sign is not unambiguously defined and depends on the magnitude of the moments and the variables. Clearly, for some values of C_2 and C_3, it is possible to obtain a negative second derivative, which implies $b_2 < 0$ in the Barkai-Levhari model. When $\mathrm{cov}(a_1, a_2) < 0$, even the sign of the first derivative is not unambiguously defined. Of course, these conclusions depend on the formulation of the assumed growth function, but as long as $\mathrm{cov}(a_1, a_2) \geq 0$, the sign of the first derivative of $E(Y_t)$ with respect to T_t is always positive.

In conclusion, I have shown that attributing an increase in output to time is correct, but it may be a result of an estimation problem and not due to technological progress or experience. Indeed, the hypothesis that these factors increase the productivity (possibly at a decreasing rate) cannot be rejected, but it is questionable whether we can "accept" it without further refinement of the suggested model,

[4] An anonymous referee pointed out to me that some of the smallest and marginal producing units are the oldest. The paper suggests that in any case where there is a systematic relation between the size of the firm and its age, the conclusions regarding "productivity" and "experience" should be regarded with caution. Clearly, the analysis is confined to economies where the assumption holds.

[5] To illustrate, $X_{it} = X_{i0}e^{z_iT_t}$ for $0 < z_i < 1$, or $X_{it} = X_{i0}T_t^{z_i}$ for $0 < z_i < 1$, or $X_{it} = X_{i0}z_iT_t$. Even in the latter case of linear combination of the X_i's and T, there is no problem of multicolinearity, since the factors are transformed to their logarithm.

[6] The estimation of random coefficients is treated in Theil (p. 622) and Hildreth and Houck and applied to the Cobb-Douglas production function with random elasticities in Amihud.

which should isolate the effect of randomness in elasticities from the age of the producing entities.

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Using the Consumer Price Index as Part of the Index of Prices Paid by Farmers: An Evaluation

James P. Houck and Mary Smaciarz

Beginning January 1977, the Statistical Reporting Service made a major change in its monthly *Index of Prices Paid by Farmers* (USDA 1976a).[1] The subgroup index of prices paid for family living items (FLI), computed within the U.S. Department of Agriculture, was replaced by the national consumer price index (CPI), computed by the Bureau of Labor Statistics (USDA 1977). The FLI contained about 150 regularly priced items, while the CPI covers about 400 goods and services. Collection and publication of price data for farm family living items was discontinued in the USDA after January 1977.

This particular change was presaged in May 1976 by a revision that introduced two CPI subgroup price indexes into the FLI (USDA 1976b). These were the indexes for medical and health care and for education, recreation, and other. These revisions broadened the FLI to include components of family living expenditures not previously covered. The subsequent adoption of the full CPI in place of the FLI reflects the general view that economic and social differences between family life on the farm and in the city have dwindled sufficiently so that a separate index for farm families is unnecessary. Furthermore, adoption of the CPI significantly reduces data collection and handling costs within the USDA. With the CPI, the family living component of the total prices paid index (PPI) remains at 30.4%. The balance of the PPI includes production items, interest, taxes, and farm wage rates.

The purpose of this note is to present some background analyses related to this change.[2] First, the historical statistical relationship between the CPI and the FLI is presented. Second, the simulated effect of using the CPI in the PPI over the historical period is analyzed along with implications for the parity ratio and some representative parity prices. Technical differences between the CPI and the FLI in their coverage and computation are not discussed here nor are the administrative, legal, and other complexities that attended dropping the FLI in favor of the CPI.

Comparing the FLI and the CPI

The analysis used official monthly data on various indexes over the eleven-year period, January 1965 through December 1975 (USDA 1976b, U.S. Dep. Labor). The May 1976 revision of the major agricultural price indexes fixed January 1965 as the link date with the previous weighting regime. All pertinent indexes and subgroup indexes were officially revised back to that link date. The indexes used in this study were expressed on the current official base (1967 = 100).

The relationship between the FLI (as revised in May 1976) and the CPI is illustrated in figure 1 for the 132-month period, January 1965 to December 1975. Because they measure essentially the same phenomena, the two indexes move closely together. The published CPI increased steadily over the period, but the FLI decreased from time to time. Also, neither the FLI nor the CPI increased faster than the other over the entire period. If the rate of increase is considered, the main discernible pattern occurs in the most recent two to three years when the FLI increased more rapidly than the CPI. Before mid-1973, the CPI was higher than the FLI and, for the three previous years, remained a rather stable two to three points above it.

Simple correlation analysis between the FLI and the CPI reveals that, over the eleven-year period, 99.1% of the monthly variation in the FLI is associated with variation in the CPI. This regression equation with the estimated standard errors of the coefficients in parentheses is

$$(1) \quad FLI = \underset{}{-7.22} + \underset{(1.09)}{1.062}\ CPI;\ r^2 = 0.991. \qquad (0.009)$$

The proximity to 1.0 of the estimated coefficient on the CPI suggests that, on a 1967 base, the two indexes are virtually interchangeable insofar as month-to-month changes are concerned. (However, the extremely high correlation between the two indexes makes the difference between the estimated coefficient and 1.0 statistically significant at the 1% level.) The regression coefficient slightly greater than 1.0 indicates that observations in the 1974–76 period, when the FLI was higher and ac-

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James P. Houck is a professor and Mary Smaciarz is a graduate research assistant in the Department of Agricultural and Applied Economics, University of Minnesota.

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[1] The official title of this index is "The Index of Prices Paid by Farmers for Commodities and Services, Interest, Taxes, and Farm Wage Rates." When expressed on the 1910–14 base, it is also known as the "Parity Index."

[2] The authors conducted this research in 1976 as consultants to the Statistical Reporting Service, USDA, but remain solely responsible for the contents of this note.

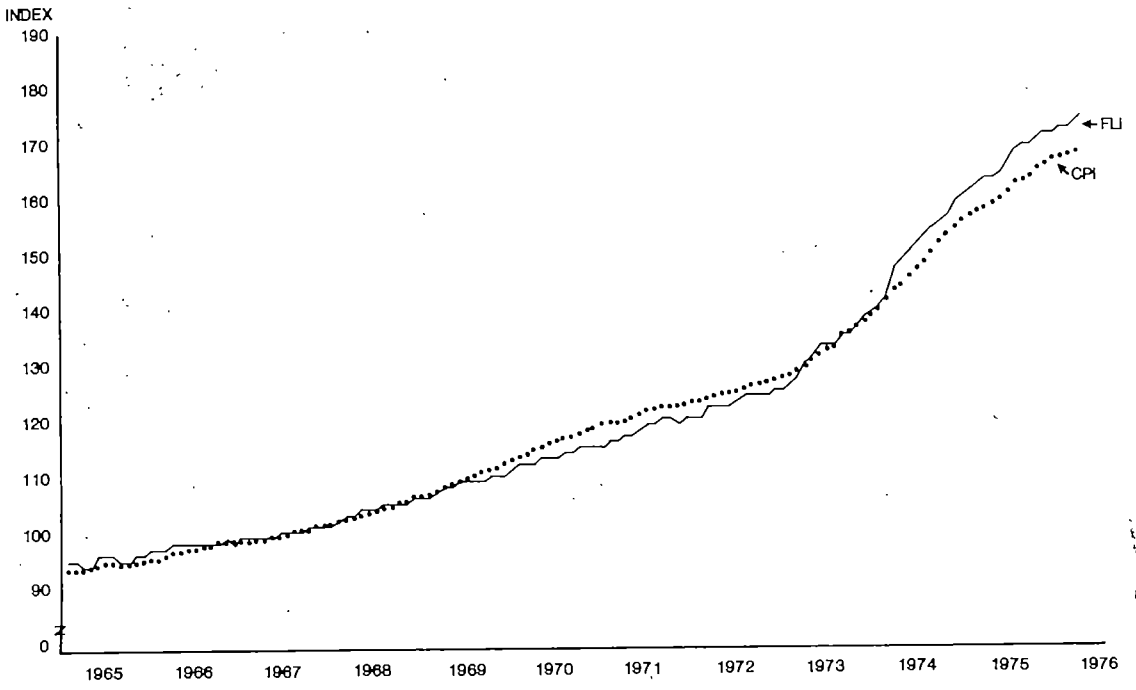


Figure 1. The consumer price index (CPI) versus the family living index (FLI) (1967 = 100)

celerating faster than the CPI, statistically dominate those of the preceding years when the CPI was higher.

The fidelity of the two indexes in registering month-to-month price level changes also is of interest. First differences of the two indexes from January 1965 to January 1976 were analyzed with simple regression. The estimated equation is

$$(2)\quad \Delta FLI = -0.706 + 1.191\ \Delta CPI;\ r^2 = 0.388. \quad (0.093)\ \ (0.134)$$

The standard errors are in parentheses and Δ denotes first differences. As expected, r^2 dropped dramatically since, with first differences, trend effects are reduced. This estimated coefficient also indicates that a one-point change in the CPI is associated with an approximate one-point change in the FLI. In this case, the difference between the estimated coefficient and 1.0 is not statistically significant. Although the overall correlation of first differences is not very high, actual versus estimated values of first differences of the FLI over the sample period using equation (2) show very few reversals or opposite movements. In only three of 132 observations did the estimated value of the FLI, based on changes in the CPI, move opposite to the actual change.

Under current practice, the agricultural price indexes are computed and published late in the same month to which they apply. However, the CPI for any given month is not available until the middle of the following month. Consequently, the one-month lagged value of the CPI (denoted CPI_{t-1}) is now being used to compute the index of prices paid by farmers.

The simple correlation between the FLI and CPI_{t-1} is also very high with about 99% of the variation in the FLI associated with variation in CPI_{t-1}. The relevant regression equation is

$$(3)\quad FLI_t = -8.343 + 1.076\ CPI_{t-1};\ r^2 = 0.990. \quad (1.145)\ \ (0.009)$$

The estimated coefficient on CPI_{t-1}, equation (3), is very nearly the same as that on the CPI, equation (1). It is clear that, over the historical period, either CPI_t or CPI_{t-1} could be regarded as a proxy for FLI_t with little loss of information.

Simulated Effects

The PPI was recalculated monthly over the January 1965 to December 1975 period using CPI_{t-1} instead of FLI_t. The simple coefficient of determination (r^2) between the actual and simulated PPI is 0.9995. The largest discrepancy is less than half of 1% of the average value of the PPI. Thus, almost nothing was altered by using a one-month lagged value of the CPI in the computation of the full prices paid index.

The parity ratio is the ratio of the index of prices received by farmers to the index of prices paid. The parity ratio, adjusted for government price support payments to farmers, is a traditional statistical yardstick by which farmers' economic welfare is gauged. Figure 2 illustrates how the historical ad-

Table 1. Parity Prices: Actual and Computed Using Estimated Values of the PPI

Item	November 1976			December 1976		
	Actual Parity Price	Computed Parity Price[a]	Difference	Actual Parity Price	Computed Parity Price[a]	Difference
Cotton: upland (¢/lb.)	78.84	78.00	−0.84	79.44	78.60	−0.84
Wheat ($/bu.)	4.86	4.80	−0.06	4.89	4.84	−0.05
Milk ($/cwt.)	12.10	11.96	−0.14	12.20	12.05	−0.15
Beef cattle ($/cwt.)	56.80	56.22	−0.58	57.30	56.66	−0.64
Hogs ($/cwt.)	52.20	51.68	−0.52	52.60	52.07	−0.53
Soybeans ($/bu.)	7.23	7.15	−0.08	7.28	7.21	−0.07
Peanuts (¢/lb.)	27.3	27.0	−0.3	27.5	27.2	−0.3

[a] In the computations, the FLI was replaced by CPI_{t-1}. Actual parity prices are from USDA 1976a.

justed parity ratio was affected by substituting CPI_{t-1} for FLI_t in the prices paid index. Only very small differences occur between the actual and the calculated values of the adjusted parity ratio. There are no reversals of turning points, and actual differences are barely discernible.

Parity prices are specific calculations applying to individual commodity prices. At any given time, they reflect the level that prices would have to achieve in order to give units of that product the same purchasing power, when sold, as they enjoyed in some designated base period. The PPI plays an important role in the formulas used to compute all parity prices. Hence, any changes in the PPI will have a potential impact upon parity prices and, by extension, on any farm price and income programs that are linked to parity.[3]

Table 1 contains some recent actual parity prices and those that would have occurred if CPI_{t-1} had been used in the calculation of the PPI. The items were selected to be representative of important commodity classes. The actual and computed parity prices in the table are directly comparable. All of the computed differences for these two months are about 1% of actual parity prices. Similar calculations for other months in 1976 show almost identical results. The conclusion is clear; the replacement of the FLI by CPI_{t-1} would have had very little effect on either the index of prices paid by farmers or parity calculations.

[3] Under current legislation, target price adjustments are linked to an index of prices paid for production, interest, taxes, and farm wage rates. Consequently, this substitution would not affect target price levels.

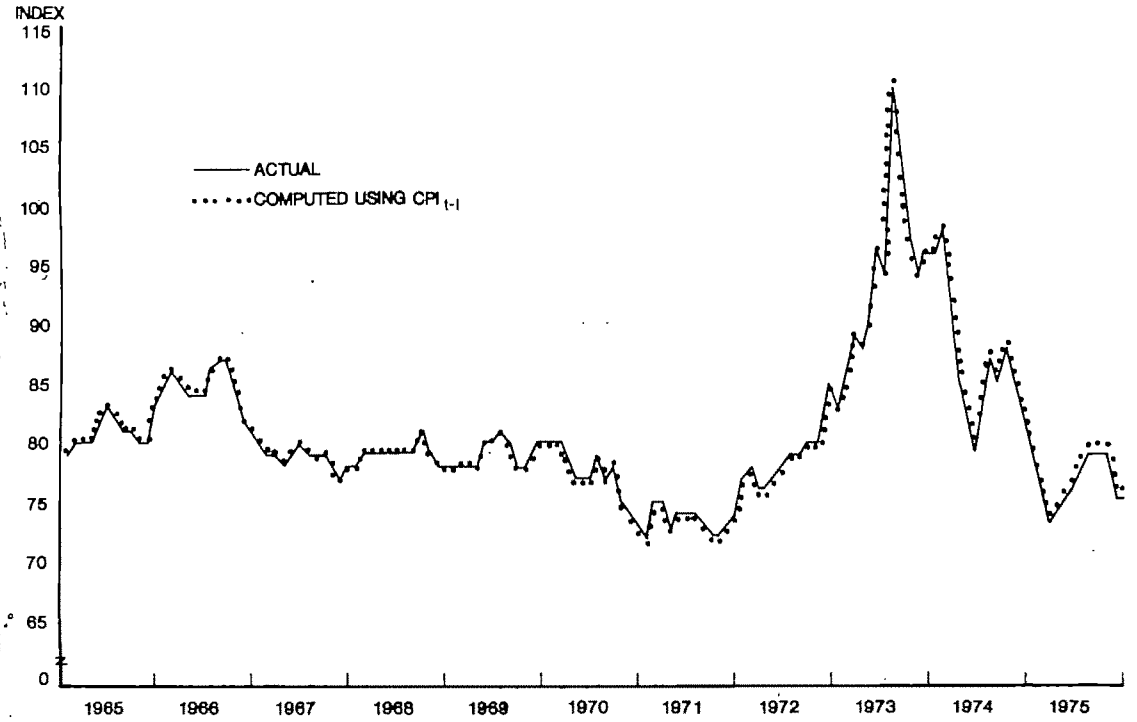


Figure 2. Adjusted parity ratio (1967 = 100)

The Linking Process

The actual transition from the FLI to the CPI in January 1977 was accomplished by a chaining computation that compensates for different levels of the two indexes. Consequently, the PPI, parity ratio, and all parity price levels in January 1977 are unaffected by the changeover. No official revisions of earlier PPI data are envisioned by the USDA. For measuring prices paid for family living items, the FLI is the official subindex until January 1977, and the CPI is the official subindex from that month onward.

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The Elasticity of Foreign Demand for U.S. Agricultural Products

Paul R. Johnson

Not unexpectedly, the upheavals in world agricultural markets in recent years have led to an increased interest in international trade problems in the agricultural economics literature. In order to quantify our analytical insights into these problems, we need empirical estimates of a host of basic relationships. Data problems and identification problems plague the international trade researcher. These problems are well known and are not pursued here. Their presence, however, has led to the adoption of some useful devices to reduce the empirical burden and to utilize existing estimates of various parameters. One such device is the subject of this note.

The quantity demanded of any one country's exports of a commodity is identically equal to the quantity demanded in the rest of the world minus the quantity supplied by the rest of the world. When this identity is differentiated with respect to price, the well-known elasticity of excess demand can be derived:

$$\eta_X = \eta_R \frac{D_R}{X} - \epsilon_R \frac{S_R}{X}, \tag{1}$$

where η_X is the elasticity of excess demand, η_R is the demand elasticity in the rest of the world, ϵ_R is the corresponding supply elasticity, D_r and S_R are rest of the world consumption and production, and X is the quantity of exports of the country in question. This kind of elasticity only requires estimates or knowledge of the demand and supply elasticities and normally available information on quantities. An estimate such as equation (1) is often useful in its own right for analytical purposes. It also can be combined with estimates of the domestic elasticity to find the elasticity of demand for the total output of a particular commodity in a nation.

Tweeten (1967) uses a relation like equation (1) in an attempt to estimate the elasticity of demand for all U.S. farm output. His basic goal is to aggregate across all farm commodities and both domestic and foreign markets. His use of the excess demand formulation is to add the foreign component to his domestic analysis, where in the latter he utilizes some of his own empirical results. Tweeten's recognition of the foreign demand component for U.S. farm output and the necessarily "large" magnitude for its elasticity is important. Unfortunately, his estimation technique for the foreign (or excess) demand component is substantially in error.

The reason for my concern with the error in calculating the foreign demand elasticity is that the estimate may get institutionalized in the agricultural economics literature. I have seen the elasticity referred to recently in several different contexts. For instance, Lopes and Schuh utilize it in an analysis of the effect of the exchange rate on agriculture. Tweeten (1975) himself has defended the estimate as a unique and important contribution. There is a danger, then, that this estimate might, through repetition, become a datum for analysis of certain agricultural policy problems. The danger, strangely enough, is mitigated by the fact that the number itself is not in error. As I show below, one can get a number in the same neighborhood as Tweeten's but with a correct procedure. I raise the issue only so the unwary will understand that the technique is the problem.

Tweeten (1967, p. 361) proposes to calculate "the price elasticity of demand for U.S. food and feed exports . . ." from the following expression (his equation (61)):

$$E_{ef} = \sum_{i=1}^{n} \left[E_{di} E_{pi} \frac{Q_{di}}{O_{ef}} - E_{si} E_{pi} \frac{Q_{si}}{O_{ef}} \right], \tag{2}$$

where E_{di} and E_{si} are the domestic price elasticities of supply and demand in country i, E_{pi} is an elasticity of prices in i with respect to U.S. market prices, Q_{di} and Q_{si} are quantities demanded and supplied in i, and O_{ef} is U.S. farm exports. E_{pi} is set equal to one and can be ignored. Tweeten then adopts previous calculations of demand or supply elasticities for foreign countries and calculates an excess demand elasticity for each of eleven countries or regions. By equation (2) he adds them up. His sum is equal to -15.85. He concludes that the coefficient is too large and proceeds to scale it down by various procedures to get a long-run elasticity of -6.42, which he then uses as his long-run demand elasticity for U.S. agricultural exports.

The source of the error is clear. The elasticity for a market with many participants is equal to the quantity weighted average of the various participants and not the sum. This piece of price theory is available in Stigler among other places.

A correct procedure for this kind of calculation can be found in Floyd and in Johnson. In order to

Paul R. Johnson is a professor in the Department of Economics, North Carolina State University.

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gauge the magnitude of the number Tweeten was seeking, I have made some very rough calculations. To make these calculations, one must take into account two kinds of aggregation problems. Farm output (or less generally, food) is an aggregate of many commodities. The market for U.S. exports is an aggregate of many national markets. Tweeten avoids for the most part the first aggregation problem by looking at the foreign demand for the composite good. His treatment of the country aggregation problem is the source of his measurement error. My approximation to equation (1) is based on assuming that domestic demand and supply elasticities for individual commodities are the same in all countries that import U.S. agricultural commodities. This assumption would not appear to be too much at variance with the real world, and it avoids altogether the aggregation problem across regions. I do consider, however, the aggregation across commodities. There is a large stock of estimates of elasticities for various commodities that could properly be termed consensus estimates. These elasticities for major exports can be used for calculating commodity excess demand elasticities and then aggregated into an export demand elasticity for U.S. agricultural products as a whole.

The basic information for this calculation is shown in table 1. The domestic demand elasticities everywhere are taken to be −0.2 for wheat and cotton, −0.4 for feed grains and soybeans, and −0.1 for tobacco. All supply elasticities are taken to be 0.2. These elasticities are all taken to be net of cross price relationships between groups, e.g., wheat and cotton. The second column in table 1 shows the percentage of world supply represented by U.S. exports for each commodity. The third column is calculated by a slight variant of equation (1). The reciprocal of each element in the second column is the weight on the supply elasticity. This weight plus one is the weight for the demand elasticity.[1] The third column shows the implied elasticity for U.S. exports of each commodity. The last column is the weight of that commodity in the 1970 export market basket. The weighted average of all the elasticities is shown in the last row of the table and is calculated to be −6.69.

Table 1. Market Shares, Individual Elasticities, and the Total Elasticity of U.S. Farm Exports

Commodity	U.S. Exports as Percentage of World Supply (%)	Implied Elasticity	Weight
Wheat	6.14	−6.72	0.18
Feed grains	6.14	−10.18	0.37
Soybeans	25.14	−2.8	0.26
Cotton	7.59	−5.5	0.09
Tobacco	6.24	−4.9	0.10
Total elasticity		−6.69	

This estimate is, of course, subject to reservations of its own. However, it is in line with other estimates and what is known about the world. Thus, I would surmise that the Tweeten estimate is in the right ball park. That estimate, it must be remembered, is not the basic estimate from his procedure but a scaled-down estimate. If one takes the 1970 weights of 0.86 for domestic use and 0.14 for exports of total farm, and a domestic elasticity of −0.25, one gets an elasticity of demand for total farm output of −1.15. This last estimate compares with Tweeten's long-run estimate of −1.11. His conclusion concerning the elasticity of farm output being greater than one is in fact vindicated.

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[1] One weight is D/X and the other S/X. Since $X = D - S$, $D/X = (S/X) + 1$.

The Elasticity of Foreign Demand for U.S. Agricultural Products: Comment

Luther Tweeten

I greet with sincere approbation Johnson's contribution to the professional literature on the elasticity of foreign demand for U.S. agricultural products. This elusive but highly important parameter has been neglected too long. Although his calculations lend credence to my estimate, I suggest caution in accepting our estimates as final or exact parameters to be used by the profession. Perhaps our efforts will motivate the profession toward refinements in procedures and data to provide more reliable estimates of the parameter.

Despite this overall acclaim for Johnson's contribution, it is necessary to clear up several misconceptions. He states, "Tweeten . . . himself has defended the estimate [of the foreign demand elasticity] as a unique and important contribution" (1977). I made no such assertion. Johnson apparently was referring to my statement that "Perhaps the most used, single parameter in our profession is the price elasticity of demand for farm output at the farm level. Despite its central importance to farm policy, only one estimate exists of the parameter to my knowledge" (1975, p. 183). Here, I refer to the importance of the price elasticity of demand for farm output and not to the reliability of my specific estimate of that parameter. I state, "the results are by no means exact and . . . a sizable upward bias could be present" in the export demand elasticity (1967, p. 365) and that the elasticity of demand for farm output "is highly sensitive to the choice of export demand elasticities—parameters that are not known with much reliability" (1967, p. 366). Later I write that "The exact magnitude of the elasticity of demand for farm products is unlikely ever to be known with a high degree of certainty, especially because of the difficulties in estimating foreign demand. The above [my own] estimates are highly controversial" (1970, p. 203).

Johnson states, "Unfortunately, his [Tweeten's] estimation technique for the foreign (or excess) demand component is substantially in error" (1977). The "error" to which Johnson refers is my alleged failure to properly weight respective elasticities by country or region in summing them, where the sum of the weights is equal to 1.0 (see Johnson 1970, p. 165).

It is instructive to derive my equation (see equation (2) in Johnson's note) for the elasticity of demand for U.S. exports, leaving out E_{pi}, which Johnson agrees to ignore. U.S. exports O_{ef} are the sum of the excess of demand quantity Q_{di} over supply quantity Q_{si} in region or country $i = 1, 2, \ldots, n$:

$$(1) \quad O_{ef} = (Q_{d1} - Q_{s1}) + (Q_{d2} - Q_{s2}) + \ldots + (Q_{dn} - Q_{sn}).$$

The derivative with respect to U.S. price, P, assumed also to be the world price, is

$$(2) \quad \frac{dO_{ef}}{dP} = \left(\frac{dQ_{d1}}{dP} - \frac{dQ_{s1}}{dP}\right) + \left(\frac{dQ_{d2}}{dP} - \frac{dQ_{s2}}{dP}\right) + \ldots + \left(\frac{dQ_{dn}}{dP} - \frac{dQ_{sn}}{dP}\right).$$

The elasticity of demand for exports is

$$(3) \quad \frac{dO_{ef}}{dP}\frac{P}{O_{ef}} = \left(\frac{dQ_{d1}}{dP}\frac{P}{Q_{d1}}\cdot\frac{Q_{d1}}{O_{ef}}\right) + \left(\frac{dQ_{d2}}{dP}\frac{P}{Q_{d2}}\cdot\frac{Q_{d2}}{O_{ef}}\right) + \ldots + \left(\frac{dQ_{dn}}{dP}\frac{P}{Q_{dn}}\cdot\frac{Q_{dn}}{O_{ef}}\right).$$

Letting $\frac{dO_{ef}}{dP}\frac{P}{O_{ef}} = E_{ef}$, $\frac{dQ_{di}}{dP}\frac{P}{Q_{di}} = E_{di}$, and $\frac{dQ_{si}}{dP}\frac{P}{Q_{si}} = E_{si}$, then equation (3) can be expressed as

$$(4) \quad E_{ef} = \sum_{i=1}^{n}\left(E_{di}\frac{Q_{di}}{O_{ef}} - E_{si}\frac{Q_{si}}{O_{ef}}\right).$$

In table 12 of my 1967 article, the heading "U.S. export demand elasticity imputed to" refers to the terms $E_{di}\,Q_{di}/O_{ef}$ and $E_{si}\,Q_{si}/O_{ef}$ for foreign demand and foreign supply, respectively. From equation (4), it is appropriate merely to sum these weighted quantities to estimate E_{ef}. The error to which Johnson refers does not exist.

I choose to aggregate commodities including feed grains, food grains, and soybeans, which are close substitutes in production and consumption, into a single food and feed category before using equation (4) to aggregate across countries and regions. Johnson, however, chooses the approach of aggregating elasticities across commodities rather

Luther Tweeten is Regents Professor in the Department of Agricultural Economics, Oklahoma State University.

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than across regions to derive E_{ef}. This approach has serious pitfalls. Define U.S. exports of commodity a as O_{ea}, foreign domestic demand quantity of commodity a as Q_{da}, foreign domestic supply quantity of commodity a as Q_{sa}, and price of commodity a as P_a along with similar notation for substitute commodities represented by b. Then elasticities are defined as follows:

$$E_{ea} = \frac{dO_{ea}}{dP_a}\frac{P_a}{O_{ea}}, \quad E_{da} = \frac{\partial Q_{da}}{\partial P_a}\frac{P_a}{Q_{da}},$$

$$E_{dab} = \frac{\partial Q_{da}}{\partial P_b}\frac{P_b}{Q_{da}}, \quad E_{ba} = \frac{dP_b}{dP_a}\frac{P_a}{P_b},$$

$$E_{sa} = \frac{\partial Q_{sa}}{\partial P_a}\frac{P_a}{Q_{sa}}, \quad \text{and} \quad E_{sab} = \frac{\partial Q_{sa}}{\partial P_b}\frac{P_b}{Q_{sa}}.$$

It can be shown that

$$E_{ea} = (E_{da} + E_{dab}E_{ba})\frac{Q_{da}}{O_{ea}} - (E_{sa} + E_{sab}E_{ba})\frac{Q_{sa}}{O_{ea}}.$$

If prices of food and feed move in harmony, then $E_{ba} = 1$, and that term can be dropped from the equation. E_{ef} is a weighted average of elasticities E_{ea}, E_{eb}, etc. Although it is not clear from his note, Johnson appears to have omitted from his equations the substitution effects represented by cross elasticities E_{dab} and E_{sab}. But whether he did or did not omit these terms, the profession should be aware of this potential conceptual trap in using his technique. Because of opportunities for substitution among, for example, wheat, corn, and soybeans in consumption as well as production, the weighted sum of the component own price elasticities is likely to be greater than the aggregate price elasticity for food and feed.

In summary, it is gratifying to note that the commodity disaggregation procedure used by Johnson provides an export elasticity similar to mine. Our basic methodology is quite similar. My procedure is not in error and conceptually is superior to Johnson's. A fruitful line of additional research may be direct estimates of demand equations for U.S. agricultural exports. Parameters generated thereby could improve estimates of the elasticity of demand for U.S. farm output.

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Some Welfare Implications of the Adoption of Mechanical Cotton Harvesters in the United States

Marshall A. Martin and Joseph Havlicek, Jr.

The role of technological innovation in agricultural development has been a topic of considerable interest among agricultural economists (e.g., Hayami and Ruttan). Several studies have examined the welfare consequences for society that have occurred as a result of technological change in the agricultural sector (Bieri, de Janvry, and Schmitz; Schmitz and Seckler; Martin). Although in many cases the benefits to society from technological change may be substantial, costs are often imposed on certain groups in society.

The technology used in cotton production in the United States has changed dramatically since World War II. The rate of substitution of mechanical cotton harvesters for hand labor was quite rapid. In 1950 less than 10% of the cotton crop was mechanically harvested. By 1970 virtually all cotton produced in the United States was picked by machine. The socioeconomic ramifications of the adoption of this new technology have been complex and far reaching. This note focuses on only one aspect of the economic impacts of adopting mechanical cotton pickers: the potential economic welfare gains to the producers and consumers of cotton in the United States.

The Economic Welfare Model

The concept of producers' and consumers' surplus has been dealt with extensively in the literature (e.g., Currie, Murphy, and Schmitz). Hence, the discussion in this section is primarily concerned with the specification of an appropriate analytical model for U.S. cotton production.[1] Since cotton fiber produced in the United States is consumed domestically, exported, and stored by the Commodity Credit Corporation, the model must reflect these three demands for U.S. cotton. Two demand functions are required: domestic demand and export demand.[2] A "storage rule" to account for the Commodity Credit Corporation activities is also incorporated into the model.

Total demand (D_t) is defined as the sum of domestic demand (D_d) and export demand (D_x) (figure 1). Since there was a net increase in the Commodity Credit Corporation inventories during the period analyzed (1952–69), this quantity is added to total demand to obtain the effective demand function (D) for cotton fiber produced in the United States.[3]

As the cost per pound for mechanical harvesting fell relative to hand picking, farmers tended to adopt the new technology. Hence, the adoption of the technology shifted the individual firm's cost curves downward, and the industry supply function shifted to the right.[4] The notation S_b and S_a is used to denote the supply function before and after the technological change.

In the absence of government intervention, the before and after free market prices (P_b and P_a) are determined by the intersection points of the respective supply functions (S_b and S_a) with the total demand function (D_t). If the free market prices P_b and P_a are below acceptable levels, the Commodity Credit Corporation stores cotton in order to maintain the support prices (P_b' and P_a'). This shifts D_t to the right toward D by the amount of the net addition to inventories. The quantity consumed

Marshall A. Martin is an assistant professor in the Department of Agricultural Economics, Purdue University, and Joseph Havlicek, Jr., is a professor in the Departments of Agricultural Economics and Statistics, Virginia Polytechnic Institute and State University.

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[1] Although a general equilibrium model would theoretically be more appropriate, econometric model specification and computational limitations forced the authors to use a partial equilibrium framework to empirically estimate the economic welfare effects.

[2] Since the United States has been the largest single world producer and exporter of cotton, the United States is assumed to possess some world market influence. Hence, the export demand for U.S. cotton would be expected to be less than perfectly elastic. For the period analyzed, the United States was responsible for one-third of the total world production and for one-third to one-fifth of the total world cotton trade.

[3] The Commodity Credit Corporation is treated as a residual buyer that absorbs that portion of cotton produced but not consumed domestically nor exported in a given market period.

[4] It is important to distinguish between the effects of biochemical and mechanical innovations. Both shift the supply function to the right. However, the former is predominately a consequence of an output effect (increased yield per acre), while the latter is largely the result of a cost saving effect (lower cost per unit of production with no increase in yield per acre). An attempt is made to distinguish the effects of mechanical innovations from those of biochemical innovations in the U.S. supply function in the econometric model. However, it may not be statistically possible to entirely separate the effects of those biochemical inputs, e.g., defoliants and new varieties, that were adopted to facilitate the mechanical harvesting from the direct cost saving effect of the adoption of the mechanical harvesters.

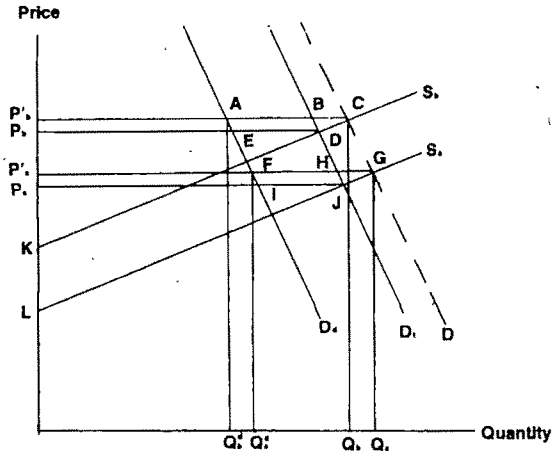


Figure 1. The consumers' and producers' surplus areas for the U.S. cotton market

domestically (Q_b^d and Q_a^d) is determined at the point where the domestic demand function (D_d) intersects the appropriate support price (P_b' and P_a'), respectively.

The gain in consumers' surplus in the United States is represented by the area $P_b'AFP_a'$ (figure 1). Consumers of cotton exported by the United States gain a consumers' surplus indicated by the area $ABHF$. The area $BCGH$ is a government consumers' surplus that is a potential gain to foreign or domestic consumers, depending on whether or not the Commodity Credit Corporation releases its inventories in the export or domestic market.

The producers' surplus gain is the difference between the after and before technological change in the producers' surplus areas. The producers' surplus areas for after and before technological change are $P_a'GL$ and $P_b'CK$, respectively. The gain to producers is $P_a'GL$ minus $P_b'CK$. The net welfare gain to the entire U.S. society is the sum of the gain in U.S. consumers' surplus ($P_b'AFP_a'$) and producers' surplus ($P_a'GL - P_b'CK$).

Econometric Model

To estimate the economic surplus, several price elasticities must be known. To obtain them, a supply and demand model for cotton fiber produced and consumed in the United States and the rest of the world is specified and estimated.

The model of the world cotton market contains five behavioral equations and two identities. All variable definitions are found in table 1. The market clearing identities are the U.S. market clearing condition:

$$(1) \qquad Y_1 + Z_{21} + Y_4 = Y_3 + Z_{19} - Z_{20},$$

and the rest of world market clearing condition:

$$(2) \qquad Y_6 - Y_4 + Z_{21} = Y_7 + Z_{22} - Z_{23}.$$

The five behavioral equations are a supply and a demand equation for the United States, a supply and a demand equation for the rest of the world, and an export linkage equation. Since the supply equations contain only one endogenous variable, they are estimated by ordinary least squares (OLS). The other structural equations (U.S. demand, rest of the world demand, and the export linkage) form an overidentified, simultaneous system of equations. These three equations are estimated by two-stage least squares (2SLS). All statistical equations are estimated in the log-linear form.[5]

The U.S. demand equation is

$$(3) \quad \log Y_1 = -86.168 + \underset{(16.474)}{26.470 \log Z_1} + \underset{(1.260)}{1.574 \log Z_2} + \underset{(0.311)}{0.103 \log Z_3} - \underset{(15.985)}{29.555 \log Z_4} + \underset{(0.500)}{0.148 \log Z_5} - \underset{(0.701)}{0.892 \log Y_2}.$$

The positive signs of the coefficients for the population (Z_1) and income (Z_2) suggest that, *ceteris paribus*, an increase in either of these variables increases demand, while the negative sign of the coefficient for trend (Z_4) indicates that over time demand declines. Although the coefficient for man-made fibers (Z_3) does not reflect a substitution of synthetic fibers for cotton fibers, there has been a substantial increase in the use of synthetic fibers in the United States in recent years.

The estimated price elasticity of demand is -0.89. Brandow and Blakley's estimates of the U.S. price elasticity of demand for cotton are -0.40 and -0.86, respectively.[6] Hence, based upon these various estimates of the U.S. price elasticity of demand for cotton, it appears to be inelastic and in a range from -0.4 to -0.9.

The U.S. supply equation is

$$(4) \quad \log Y_3 = -2.953 + \underset{(2.055)}{1.647 \log Z_6} + \underset{(0.422)}{1.287 \log Z_7} + \underset{(1.476)}{0.921 \log Z_8} - \underset{(0.578)}{0.463 \log Z_9}$$

[5] The standard errors are enclosed in parentheses under their respective regression coefficients. For the equations estimated by 2SLS, the R^2 and the Durbin-Watson statistic d are not strictly valid and are not reported. Although the rest of the world supply equation is estimated by OLS, it contains the dependent variable as a lagged independent variable, and the Durbin-Watson statistic is not reported.

[6] A distributed lag model of the type suggested by Nerlove was also estimated, but the lagged endogenous variable had a negative sign that contradicts the assumed market adjustment process over time. Thus, it was not possible to estimate a long-run price elasticity of demand. Blakley also encounters this same difficulty with some of the distributed lag models specified in his study. In an effort to reduce the effect of multicollinearity among several variables in the U.S. cotton demand equation, a per capita Nerlovian distributed lag model was also estimated. In this case the short-run price elasticity of demand was found to be -0.38 with an elasticity of adjustment of 0.78. These coefficients provide for a long-run per capita price elasticity of demand of -0.49. Based upon the elasticity of adjustment, *ceteris paribus*, it would take two years to remove 95% of an initial disequilibrium.

Table 1. Variable Definitions

Endogenous variables

Y_1 = Quantity of cotton fiber consumed in the United States excluding imports (million lbs.)[a]
Y_2 = Cotton fiber price (15/16"M) at 14 selected markets in the United States (¢/lb.)
Y_3 = Quantity of cotton fiber produced in the United States (million lbs.)
Y_4 = Quantity of cotton fiber exported by the United States (million lbs.)
Y_5 = "World" cotton fiber price (1'M), Liverpool (¢/lb.)
Y_6 = Quantity of cotton fiber consumed outside the United States (million lbs.)
Y_7 = Quantity of cotton fiber produced outside the United States (million lbs.)

Predetermined variables

Z_1 = U.S. population
Z_2 = Disposable income in the United States
Z_3 = Quantity of man-made fibers on a cotton equivalent basis produced in the United States (million lbs.)
Z_4 = Trend, 1952 = 52, 1953 = 53, etc.
Z_5 = Price index of broad woven cotton cloth (1947–49 = 100)
Z_6 = Price index of commercial fertilizer in the United States (1947–49 = 100)
Z_7 = "Support price" as announced by U.S. government (¢/lb.)
Z_8 = Composite wage rate for cotton producing states (1947–49 = 100)
Z_9 = Price of soybeans lagged one year (¢/lb.)
Z_{10} = Percentage adoption of mechanical cotton harvesters (base year 1945)
Z_{11} = Level of adoption of biochemical technology, measured as the percentage increase in cotton yields per acre (base year 1945)
Z_{12} = Quantity of man-made fiber produced outside the United States (million lbs.)
Z_{13} = Y_5 lagged one year
Z_{14} = Y_7 lagged one year
Z_{15} = "World" price of #2 corn, United Kingdom, lagged one year (¢/lb.)
Z_{16} = "World" price of soybeans, United Kingdom, lagged one year (¢/lb.)
Z_{17} = "World" price of wheat, United Kingdom, lagged one year (¢/lb.)
Z_{18} = Export subsidy paid by U.S. government to exporters (¢/lb.)
Z_{19} = Beginning year cotton inventory, United States (million lbs.)
Z_{20} = Ending year cotton inventory, United States (million lbs.)
Z_{21} = Quantity of U.S. imports (million lbs.)
Z_{22} = Beginning year cotton inventory, outside United States (million lbs.)
Z_{23} = Ending year cotton inventory, outside United States (million lbs.)

Note: All variables are measured on a crop year basis and in real terms. The deflators used were the U.S. wholesale farm price index and the U.S. prices paid by farmers index (1947–49 = 100). The year 1952 was selected as the initial date since by 1952 all states mechanically harvested at least 1% of their cotton production. This date also avoids the major market disturbances resulting from World War II and the Korean War. By 1969 the adoption of mechanical harvesters was virtually complete. Data are found in the USDA and United Nations publications.

[a] Imports are excluded so that the surplus areas correspond only to cotton grown in the United States. The U.S. imports only about 1% of its total mill consumption.

$$+ \underset{(0.233)}{0.343} \log Z_{10} - \underset{(0.148)}{0.336} \log Z_{11};$$

$$R^2 = 0.77 \text{ and } d = 1.84.$$

The coefficients for the price of fertilizer (Z_6) and labor (Z_8) have signs opposite those expected a priori and are not significantly different from zero. Apparently, there are some problems of data aggregation and specification of a supply equation that is capable of separating the substitution effect from the output effect. The coefficient of the price of soybeans (Z_9), although not statistically different than zero, has a negative sign, suggesting some substitution of soybeans for cotton.

The coefficients of the mechanical (Z_{10}) and biochemical (Z_{11}) technologies have relatively small standard errors. The positive sign of the coefficient of the mechanical technology is consistent with an increasing rate of adoption of cotton harvesters over the period. The negative coefficient of the biochemical technology suggests that, although the absolute yield per acre of cotton tended to increase as biochemical inputs were adopted, the rate of increase declined throughout the period. The short-run support price elasticity of supply is 1.29, indicating that U.S. cotton producers are quite price responsive in the short run.[7]

The export linkage equation is[8]

[7] A supply equation was also estimated with Y_3 lagged one time period. The coefficient of the lagged endogenous variable, however, was not statistically different from zero. An adjustment elasticity of one for the U.S. cotton supply function probably reflects government intervention in the form of acreage allotments, diversion payments, and related supply-control policies. A supply equation using the market price lagged one year in place of the support price produced a price elasticity of supply of 0.9. Cotton producers apparently respond more readily to the announced support price than to the previous year's market price.

[8] In those years when the world cotton price was less than the domestic price, the U.S. government paid an export subsidy to encourage cotton exports in an effort to maintain the U.S. share of the world cotton export market. Rather than estimate an export demand function, it was hypothesized that an export linkage equation would more adequately account for the U.S. policy-induced

$$(5)\quad \log Y_4 = -5.043 - \underset{(1.107)}{1.071}\log Y_2 + \underset{(1.452)}{3.799}\log Y_5' + \underset{(1.379)}{2.281}\log Z_4.$$

The results indicate that a 10% increase in the domestic price (Y_2) reduces the quantity exported (Y_4) by approximately 11%, *ceteris paribus*, while a 10% increase in the world price including the export subsidy (Y_5') increases the quantity exported by 38%. Apparently, the export subsidy substantially encouraged U.S. exports. The positive sign of the coefficient for trend (Z_4) reflects a net tendency to increase the quantity exported over time.

The rest of the world demand equation is

$$(6)\quad \log Y_6 = 1.770 + \underset{(3.808)}{1.671}\log Z_4 - \underset{(0.350)}{0.124}\log Z_5 - \underset{(0.526)}{0.051}\log Z_{12} - \underset{(0.599)}{0.031}\log Y_5.$$

The positive sign of the coefficient for trend (Z_4) is indicative of a long-run increase in the quantity demanded. Although the magnitude of the coefficient for man-made fibers (Z_{12}) is small, the sign does suggest some substitution of man-made fibers for cotton.

The short-run world price elasticity of demand is −0.03.[9] Blakley estimates a world price elasticity of demand of −0.07. Although based on rather weak statistical results, the rest of the world demand function for cotton is apparently even more inelastic than that for the United States.

The rest of the world supply equation is

$$(7)\quad \log Y_7 = -0.163 + \underset{(0.663)}{1.228}\log Z_4 + \underset{(0.199)}{0.089}\log Z_{13} + \underset{(0.314)}{0.472}\log Z_{14} + \underset{(0.265)}{0.257}\log Z_{15} - \underset{(0.195)}{0.140}\log Z_{16} + \underset{(0.213)}{0.098}\log Z_{17};$$

$$R^2 = 0.97.$$

Heterogeneity of land types, different local input prices, and divergent levels of technologies make this supply function extremely difficult to specify. Due to these problems, Blakley assumes the supply function for cotton for the rest of the world to be perfectly price inelastic. In this study, the price elasticity of supply is not significantly different from zero even at the 0.30 level; thus, the rest of the world supply function is considered perfectly price inelastic.

The parameters from the rest of the world supply and demand equations are not required for the calculations of the economic surplus areas for the United States. These two equations are mainly specified in order to close the system of equations in the world cotton model. Unfortunately, both equations give rather weak statistical results.

The Economic Surpluses

When collapsed on the geometric means of all variables except cotton price and quantity, the U.S. demand equation is

$$(8)\quad \log Y_1 = 4.954 - 0.892 \log Y_2.$$

As indicated in the discussion of the economic model, the domestic demand function (D_d) must be shifted to the right to obtain the effective demand function (D). This is done by adding the geometric means of the domestic quantity demanded (Y_1) and the quantity exported (Y_4) to the net additions to Commodity Credit Corporation inventories to get the total quantity effectively demanded ($\bar{Y}$). The consequence of this adjustment is to shift the intercept of the domestic demand function:

$$(9)\quad \log \bar{Y} = 5.130 - 0.892 \log Y_2.$$

In a similar fashion, evaluating the U.S. supply function at the geometric means of all variables except cotton price, quantity produced, and mechanical technology yields

$$(10)\quad \log Y_3 = 1.284 + 1.287 \log Z_7 + 0.343 \log Z_{10}.$$

In order to estimate the benefit stream generated by the adoption of harvesting technology, the supply function is assumed to shift one year at a time along the static effective demand function (D) by the mechanical harvesting technology variable (Z_{10}). By substituting in the observed level of adoption of mechanical cotton harvesters one year at a time, eighteen different intercept terms for the U.S. cotton supply equation can be derived. By solving simultaneously each of these eighteen supply equations with the static effective demand equation, eighteen before and after *ceteris paribus*, equilibrium price-quantity pairs are obtained.[10]

Formulas developed by Hertford are utilized to calculate the surplus areas.[11] The benefit stream

distortion between the domestic and world market prices, especially the influence of export subsidies and how they affected U.S. cotton exports. Therefore, the U.S. export price (Y_5') is equal to the world price (Y_5) plus the export subsidy (Z_{18}).

[9] A distributed lag model of the Nerlove type was also estimated. The short-run price elasticity of world demand was found to be −0.10 with an elasticity of adjustment of 0.36. The long-run price elasticity of world demand would be −0.28. The world market would require about four years to remove 95% of some initial disturbance.

[10] For purposes of solving the respective pairs of equations, it is assumed $Z_7 = Y_2$ and $Y_3 = \bar{Y}$. The average support price for the eighteen-year period was only slightly greater than the market price. Total U.S. cotton production is equal to U.S. mill consumption plus exports plus net changes in inventories. These two assumptions have only a relatively minor impact on the surplus areas.

[11] Change in consumers' surplus is

$$\left[\left(\frac{P_b - P_a}{P_a}\right)P_aQ_a\right]\left[1 - \tfrac{1}{2}\left(\frac{\epsilon\eta(P_b - P_a)/P_a}{\eta + \epsilon}\right)\right].$$

over the eighteen-year period is then discounted to a present value at a 6% rate of interest. The gain in total consumers' surplus in 1947–49 dollars was approximately $350 million with about $230 million going to U.S. consumers and $120 million to consumers outside the United States. The net increase in Commodity Credit Corporation inventories over the eighteen-year period was minimal.[12] Hence, the government consumers' surplus was negligible.

Based on the average quantity of U.S. produced cotton consumed in the period, this represents a savings to all consumers in real terms of about 5¢ per pound. In terms of the average U.S. population for 1952–69, this is a savings of approximately $1.25 per capita for consumers in the United States.

The producers' surplus gain in 1947–49 dollars was about $309 million. Based upon the average yields and number of acres harvested in the period, this represents a savings in harvesting costs in real terms of approximately 4.5¢ per pound of lint cotton or $20.00 per acre. The cost data reported in Maier's study of the adoption of mechanical cotton pickers suggest that from 1952 to 1966 the real cost per pound of lint cotton mechanically harvested relative to hand picking fell about 3¢ per pound. His study looks only at the direct substitution of mechanical harvesters for hand picking. The coefficient of mechanical technology in this study may also be reflecting other aspects of adopting mechanical pickers such as more timely harvesting and the use of defoliants. Moreover, since this study covers the period 1952–69 and since real hand picking costs continued to increase relative to mechanical harvesting costs throughout the period, one expects the cost savings to be slightly higher in this study than in the Maier study.

Cost of production data for the Mississippi Delta (USDA 1970, 1971) indicate that real labor costs for all production activities fell $28 per acre from 1960 to 1970, while real machinery costs remained virtually unchanged. Hence, a cost savings of about 4.5¢ per pound or $20.00 per acre from the adoption of mechanical cotton harvesters for 1952–69 does not seem to be unreasonable.

Conclusions

Both consumers and producers in the United States have benefited from the adoption of mechanical cotton harvesters. U.S. consumers received the larger portion of the economic welfare gains, approximately $230 million or about $1.25 per capita in 1947–49 dollars. The cost savings to the U.S. cotton producers as a result of the adoption of the harvesting technology was approximately 4.5¢ per pound of lint cotton (1.4¢ per pound of seed cotton).[13] This cost savings is about 15% of the average real price received by farmers for lint cotton during 1952–69.

The welfare gains from the adoption of mechanical cotton harvesters reported in this note are based on a partial equilibrium framework and do not reflect the direct impacts on the labor market. Although the benefits to consumers and producers were substantial, the adoption of the labor-saving technology contributed to the disequilibrium in the labor market in the South. Further research on this labor market disequilibrium should provide additional insights into the total magnitude of the social costs and benefits of the adoption of cotton harvesters.

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Change in producers' surplus is

$$\left[\left(\frac{Q_a - Q_b}{Q_a}\right) P_a Q_a\right]\left[1 + \tfrac{1}{2}\left(\frac{Q_a - Q_b}{Q_a/(\eta + \epsilon)}\right)\right],$$

where P is the price, Q is the quantity, a and b "after" and "before" technological change, respectively, η is the price elasticity of demand, and ϵ is the price elasticity of supply.

[12] In the late 1950s and early 1960s, the Commodity Credit Corporation inventories were relatively large. However, by the end of the period, government inventories were nearly depleted.

[13] Based on a USDA conversion factor of 3.26 pounds of seed cotton, including trash, per pound of ginned cotton.

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Impact of Rail Abandonment upon Grain Elevator and Rural Community Performance Measures

John J. Miller, C. Phillip Baumel, and Thomas P. Drinka

Historically, businessmen located on rural branch rail lines have strongly opposed rail abandonment. They have argued that the loss of their branch rail lines would substantially increase their costs and make it more difficult—and perhaps impossible—for elevators and farmers to market their grain and to obtain production inputs. Community leaders maintain that the very existence of their towns will be threatened if their rail lines are abandoned.

Congress also has been concerned with the impact of rail abandonment on rural communities. The Railroad Revitalization and Regulatory Reform Act of 1976 provides up to $360 million of financial assistance to states for "transitional continuation of service on light density rail lines that are necessary to continued employment and community well-being throughout the United States."

The available research on the impact of rail abandonment on rural businesses and towns is inconclusive. The studies addressing this question generally are of three types. One type attempts to project the potential impact of abandonment on communities and elevators that have rail service. Studies by Poth (1975a,b) and by Fink and Goode forecast large losses of income and/or employment from potential rail abandonment.

A second set of studies measures changes in communities and counties before and after abandonment. Due measures employment and population in two Oregon counties before and after abandonment of a branch line. Allen measures population growth, transportation costs, and firm adjustments within ten communities before and after abandonment. Due and Allen conclude that the short- and long-run effects of abandonment were relatively small.

A third set of studies compares the growth of firms and counties affected by abandonment with the growth of nearby firms and counties that continued to have rail service. Bunker and Hill measure the impact of rail abandonment on agricultural production and on associated grain-marketing and fertilizer-supply firms located on two abandoned rail lines by comparing the growth of the firms located on the abandoned lines with the growth of nearby firms. The chief impact was on fertilizer dealers. There was no clear indication that abandonment had any significant impact on employment.

Sloss, Humphrey, and Krutter attempted to measure the overall effects of rail abandonment on the development of nine test counties that had lost a major portion of their rail mileage. These nine counties were compared with nine control counties that had either no abandonment or relatively little abandonment. They find no significant impacts attributable to abandonment using economic indicators such as changes in total bank deposits, changes in total value added by farm products, changes in number of employees in manufacturing, etc. Measures of total economic activity on a county basis, however, may be too aggregative to measure accurately the impact of rail abandonment on individual businesses and communities.

Many communities already have lost their rail lines. Thus, it should be possible to measure statistically the effect of rail abandonment on performance measures of businesses and communities by comparing the change in performance measures over time of the businesses and communities that have lost their rail service with the change in these performance measures of similar businesses and communities located on branch rail lines. It should then be possible to determine if significant statistical differences occur in the change in performance measures of the two groups of businesses or communities. This note compares certain performance measures of cooperative elevators and incorporated towns in Iowa that lost their rail lines before 1974 with the performance measures of cooperative elevators located on all rail lines in Iowa and of incorporated towns served exclusively by seventy-one Iowa branch rail lines recently studied for possible upgrading or abandonment (Baumel, Miller, and Drinka 1976, 1977). These seventy-one branch lines, which generally serve rural areas in Iowa, are considered as potential candidates for abandonment.

The towns on these seventy-one branch lines were chosen as the control group because of their similarity in size and type of economic activity with the towns already abandoned. The major difference between the control and treatment groups is that almost all of the communities on the seventy-one lines

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John J. Miller is a research associate, C. Phillip Baumel is a professor, and Thomas P. Drinka is a postdoctoral research associate in the Department of Economics, Iowa State University.

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have vigorously opposed abandonment and have worked aggressively to generate additional traffic to justify keeping the rail line. Some of the communities and shippers have raised private funds that, combined with state government funds, have been used to upgrade their rail lines. Most of the upgraded lines generate very large volumes of rail shipments. The upgraded lines as well as the lines with shippers who are successful in increasing the rail traffic are likely to remain in operation.

Methodology

According to Steiner, the major criteria used by the Interstate Commerce Commission to evaluate individual rail abandonment petitions are (*a*) historical levels of carloadings, (*b*) historical levels of railroad profits or losses from the line, (*c*) availability and cost of alternative transportation, and (*d*) other considerations such as rail line rehabilitation costs or previous commitments to shippers. The criteria weighted most heavily by the Interstate Commerce Commission are the level of railroad profits or losses from the line and the historical volume of traffic on the line. Therefore, rail lines serving communities and shippers with small volumes of freight are more likely to be abandoned than are rail lines serving communities and shippers with large volumes of freight. Thus, an analysis of absolute values of performance measures of communities and shippers is likely to lead to the conclusion that railroads serving communities and shippers with small freight volume are more likely to be abandoned than are lines serving communities and shippers with large freight volume. To avoid the "chicken-egg" issue of whether rail lines affect community and elevator size or whether community and elevator size affect the presence of the rail line, this analysis is based on percentage changes in the performance measures of communities and elevators located on abandoned rail lines compared with communities and elevators located on rail lines; that is, this analysis determines whether the rates of change of the performance measures are different between the communities and elevators with and without rail service. These effects can be termed the "secondary effects" of rail abandonment.

An analysis-of-variance model was used to test the null hypothesis of no significant differences in the yearly percentage change of each of the measures between the cooperatives or towns that had already lost rail service and the cooperatives located on rail lines or towns still served by the seventy-one branch lines studied. The model used is

$$Y_{ijk} = u + \alpha_i + \beta_j + \alpha\beta_{ij} + \epsilon_{jk},$$

where Y_{ijk} is the performance measure for the kth individual in the jth year and ith group, u is the grand mean, α_i is treatment effects ($i = 1$ = abandoned rail line towns and $i = 2$ = towns on the seventy-one study lines), β_j is replication effects (j = index of years), $\alpha\beta_{ij}$ is the interaction between the treatment and years, and $\epsilon_{jk} = v_k + e_{jk}$, where v_k is the random error associated with the kth individual and e_{jk} is the random error associated with the jth measurement for the kth individual. The random errors v_k and e_{jk} are assumed independently distributed with zero means and with variances σ_v^2 and σ_e^2, respectively, where $\sigma_v^2 \geq 0$ and $\sigma_e^2 > 0$. This model is the one-fold, nested-error type (Fuller and Battese). The covariance structure of the random errors ϵ_{jk} in this model is expressed by

$$\begin{aligned} E(\epsilon_{jk}\epsilon_{j'k'}) &= \sigma_v^2 + \sigma_e^2 \text{ if } k = k' \text{ and } j = j', \\ &= \sigma_v^2 \quad \text{if } k = k' \text{ and } j \neq j', \\ &= 0 \quad \text{if } k \neq k'. \end{aligned}$$

The estimation procedure for the model consists of two steps. First, the variance components (σ_v^2 and σ_e^2) are estimated by the fitting-of-constants method (Searle). If $\sigma_v^2 > 0$, the Fuller and Battese method is used to compute a matrix of transformed variables for the estimates of the variance components. Least squares is then applied to the matrix of transformed variables to obtain least-square estimates. If $\sigma_v^2 = 0$, then least squares is applied to the original variables. A two-tailed F-test is used to test the null hypotheses that $\alpha_1 = \alpha_2, \beta_1 = \beta_2 = \ldots = \beta_n$, and $\alpha\beta = 0$.

Results

The cooperative elevator performance measures (the alternate Y_{ijk}'s) used in this study include total sales, return on investment, total assets, grain sales, and fertilizer sales for the years 1969–74. The sample of elevators analyzed consists of cooperatives audited by a regional grain cooperative. Financial data were obtained from the audited financial reports of cooperative elevators that had lost rail service and from cooperative elevators still located on rail lines (Farmers Grain Dealers Association of Iowa). The cooperatives in the group with rail service include only the 138 cooperatives audited by the regional cooperative each year from 1969 to 1974.

The group of cooperatives that had lost rail service include only those that had no facilities with access to rail lines; cooperatives were added to this group the year after abandonment of the rail line. The number of cooperatives in this group ranged from five in 1969 to twelve in 1974.

The unweighted average yearly percentage changes in total sales, grain sales, fertilizer sales, and total assets and percentage return on investment for the two groups of cooperatives are presented in table 1. The data in table 1 are unweighted average percentage changes, where n is the number of cooperative elevators in the previous year. Because the return on investment measure was automatically adjusted for elevator size when total earnings were divided by total assets, this measure was not converted to an annual percentage change.

Table 1. Unweighted Average Percentage Change in Selected Performance Measures of Two Cooperative Elevator Groups, Iowa, 1969–74

Performance Measure	1969	1970	1971	1972	1973	1974
Total sales[a]						
On abandoned lines[b]	—	22.7	27.3	−0.8	51.6	51.0
On existing lines	—	32.6	17.2	1.6	53.7	59.6
Grain sales[a]						
On abandoned lines[b]	—	35.0	31.4	2.0	73.4	65.7
On existing lines	—	45.3	23.0	1.0	65.4	73.5
Grain sales (bu.)[a]						
On abandoned lines[b]	—	25.7	13.6	1.1	37.1	10.7
On existing lines	—	35.2	6.1	1.0	30.6	22.4
Fertilizer sales[a]						
On abandoned lines[b]	—	6.9	59.4	1.0	26.8	78.5
On existing lines	—	11.5	23.2	−4.1	37.6	92.8
Total assets[a]						
On abandoned lines[b]	—	26.0	15.6	11.0	32.6	26.7
On existing lines	—	13.4	5.4	14.5	36.9	13.4
Return on investment						
On abandoned lines	11.1	10.5	6.6	7.5	12.9	20.4
On existing lines	6.1	7.0	6.5	6.8	10.8	18.5

Source: Farmers Grain Dealers Association of Iowa.

[a] Percentage change from previous year.

[b] Based on number of cooperative elevators in the previous year.

The computed *F*-statistics and degrees of freedom from the analysis of variance of the cooperative data are presented in table 2. The computed *F*-statistics for years indicate significant differences for all measures at the 99% confidence level. The computed *F*-statistics for the treatment (rail service) and the interaction terms indicate no significant differences between the two groups of cooperatives.

The high level of significance among years for all measures is largely a result of the rapid growth in the export demand for feed grains and soybeans during 1969–74. The growth in exports was caused primarily by widespread drought in many parts of the world combined with the devaluation of the U.S. dollar. This growth in the demand for feed grains resulted in increased sales and earnings for almost all cooperatives.

The lack of significance of the treatment (rail service) and interaction terms seems reasonable given the data in table 1. Only small differences exist in the rate of growth of the two groups of cooperatives. These results suggest that cooperatives located on abandoned rail lines do not die but rather continue to grow. A similar conclusion can be drawn from the average percentage return on investment data. While the cooperatives located on abandoned rail lines experienced slightly higher rates of return on investment than did the cooperatives with rail service, the average return on investment of the two groups followed similar patterns of change over the six-year period.

According to the managers of the cooperatives located on abandoned rail lines, the abandonment of their rail line induced them to completely reevaluate

Table 2. Analysis of Variance Results for Percentage Change in Performance Measures of Cooperative Elevators, Iowa, 1969–74

Performance Measure	Computed *F*-Statistics and Degrees of Freedom		
	Year	Treatment (Rail Service)	Interaction
Total sales	$94.41^{a}_{(4,713)}$	$0.39_{(1,713)}$	$0.39_{(4,713)}$
Grain sales	$72.60^{a}_{(4,711)}$	$0.01_{(1,711)}$	$0.26_{(4,711)}$
Grain sales (bu.)	$11.16^{a}_{(4,707)}$	$0.05_{(1,707)}$	$0.18_{(4,707)}$
Fertilizer sales	$46.24^{a}_{(4,684)}$	$0.002_{(1,684)}$	$0.49_{(4,684)}$
Total assets	$31.90^{a}_{(4,713)}$	$1.84_{(1,713)}$	$0.83_{(4,713)}$
Return on investment	$41.66^{a}_{(5,862)}$	$1.49_{(1,862)}$	$0.19_{(5,862)}$

[a] Significant at the 99% confidence level (Snedecor and Cochran).

Table 3. The Analysis of Variance Results for the Community Performance Measures

Growth Measure	Computed F-Statistics and Degrees of Freedom		
	Years	Treatment (Rail Service)	Interaction
Population	$4.29_{(1,557)}$	$0.04_{(1,557)}$	$0.89_{(1,557)}$
Retail sales	$62.11^{a}_{(4,583)}$	$0.04_{(1,583)}$	$1.81_{(4,583)}$
Bank demand deposits	$79.96^{a}_{(8,1414)}$	$0.81_{(1,1414)}$	$1.47_{(8,1414)}$
Bank loans and discounts	$13.44^{a}_{(8,1414)}$	$0.05_{(1,1414)}$	$0.37_{(8,1414)}$
Bank surplus, reserves, and undivided profits	$26.63^{a}_{(8,1414)}$	$0.0002_{(1,1414)}$	$0.52_{(8,1414)}$

[a] Significant at 99% confidence level (Snedecor and Cochran).

the operations of their cooperatives. This, in turn, led to the elimination of unneeded labor and equipment, to improved marketing practices, and to a search for new product lines and enabled them to continue to grow in sales, assets, and earnings. Therefore, the calculated F-statistics combined with an evaluation of the raw data on the growth of the performance measures of the cooperatives suggest that the null hypothesis of no significant differences in the performance measures of the two groups of cooperatives should not be rejected.

The performance measures (Y_{ijk}'s) of incorporated towns located on abandoned rail lines and of incorporated towns located on the seventy-one study lines include population and retail sales. In addition, data on bank demand deposits, bank loans and discounts, and bank surpluses, reserves, and undivided profits were obtained for state banks located in each set of towns. Bank demand deposits and bank loans and discounts can be interpreted as gross measures of income in the communities. Bank surpluses, reserves, and undivided profits are approximate measures of bank profitability. Employment data are available only by county and, therefore, were not used in this analysis. All towns included in the abandoned groups had lost their rail lines before the beginning of each time period.

Table 3 presents the analysis-of-variance results. The computed F-statistics for years indicate significant differences among years in the performance measures. Evidently, the significant difference was caused primarily by a rapid growth in agricultural output and, hence, rural income during the years included in the analysis. The computed F-statistics for the treatment (rail service) indicate no significant differences in the five performance measures between incorporated towns and banks located on abandoned rail lines and the incorporated towns and banks located on the study rail lines. The computed F-statistics for interaction indicate no significant differences in the effect of abandonment on the performance measures among years.

Conclusions

The results indicate that, contrary to popular opinion, cooperatives located on abandoned rail lines do not die but rather continue to grow. When the performance measures were converted to percentages to adjust for elevator size, the data indicate no differences in rate of growth in the performance measures. If additional explanatory variables were considered in the analysis-of-variance model, a larger proportion of the total variation might be explained; however, the raw data suggest that the treatment F-statistics would likely show little change. With respect to community measures, no significant F-statistics existed for treatment (rail service) or for interaction. The results of this statistical analysis tend to confirm the conclusions of case studies that suggest minor or negligible impacts of rail abandonment on rural towns and elevators.

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Recreation Program Development Impacts: A Dynamic Regional Analysis

Nicholas Brown and James A. MacMillan

Controversy exists with respect to the effectiveness of outdoor recreation programs in contributing to regional development. According to Garbacz, recreation may be the major economic opportunity for revitalizing some rural areas. In contrast, Meyer observes that past studies do not confirm the common assertion that tourism-recreation has the potential for stimulating the economies of distressed areas. The lack of adequate data on regional impacts of concern to local, provincial, and federal interest groups in Canada (as well as the United States) has delayed the construction and development of national parks proposed to preserve unique ecological landscapes or to create new recreational opportunities (MacMillan, Lyon, and Brown; Clawson and Knetsch).

Analysis to date has not compared recreation with other development programs and has been limited to measuring the importance of visitor expenditures (Beyers, Hinman). Critical issues that have been neglected include the impacts associated with park construction, operation, manpower training, visitor expenditures, and income distribution. The primary purpose of this note is to compare impacts of a recreation program relative to agricultural development programs utilizing a dynamic regional economic model developed by Tung, MacMillan, and Framingham. This note is organized into three sections: (*a*) inclusion of recreation in a regional model, (*b*) an assessment of recreation versus agricultural development programs, and (*c*) development policy implications. The results indicate a low level of recreational impacts relative to agricultural program benefits. Thus, recreation may often be oversold as a stimulus for regional development.

Inclusion of Recreation in a Regional Model

Development of outdoor recreation resources stimulates regional growth primarily from the "demand side," generated from the exogenous increases in the final demand sector associated with government capital, and operations and maintenance expenditures and visitor expenditures by recreationists attracted to the region.[1] In the model described here, these impacts are calculated in three stages. First, economic impacts are simulated in the model without recreation programs to determine base values for economic development indicators. The effects of the recreation program are then included in a rerun of the model. Second, distributional impacts are estimated. Third, recreation impacts are compared with those generated from other development programs.

The recreation impact estimation developed here is based upon a modification of a dynamic regional input-output system estimated by Tung, MacMillan, and Framingham. This model is modified to incorporate the recreation program expenditures by sector with the addition of four vectors to the initial final demand vector in year t, including park capital expenditures, total nonwage operations and maintenance expenditures, regional household expenditures resulting from wage and salary payments in operations and maintenance and manpower training programs, and visitor expenditures due to the park. The elements of the household expenditures vector associated with wage, salary, and trainee payments are derived from proportional allocation to sectors of commodity group expenditures estimated by Engel functions.[2] The elements of the visitor expenditure vector are estimated by proportional allocation by sector of estimated day-use and camping party expenditures. The 1976–78 visitation projections are based on average annual growth rates of 37%, 27%, and 11%, respectively, to approximate rapid increases in initial years and a gradual decline to the provincial average growth rate.

The distributional impacts involve estimation of the impact of the recreation program on low-income households. There are three dimensions to the distributional impacts. First, the recreation facility is used primarily by high-income visitors from outside the rural region. Second, the park facility construction was used as a training project for low-income unemployed rural residents. Third, seasonal jobs associated with visitor expenditures primarily in the personal service sector are relatively low-wage occupations. Recreation impacts in low-income households are realized primarily in the construction phase of the project.

Nicholas Brown is a research associate and James A. MacMillan is a professor in the Department of Agricultural Economics, University of Manitoba, Canada.

[1] Tourism generally involves all travel for whatever reason when the trip made is not part of a daily routine, whereas outdoor recreation at parks relates solely to those trips made voluntarily during leisure time.

[2] Engel functions have been estimated for eleven commodity groups in the Interlake Area (Tung, pp. 209–18).

An Assessment of Recreation versus Agricultural Development Programs

The recreation program examined in this study was developed as part of an area rural development plan in the Interlake Area of Manitoba. The program is jointly funded by the Province of Manitoba and the Canada Department of Regional Economic Expansion. The broad objectives of the rural development plan are to increase income and employment opportunities and standards of living. Other development programs include education, drainage, land clearing, manpower training, and fisheries adjustment. The objectives of the recreation program are to enhance and complement the Manitoba recreational areas within 100 miles of Winnipeg along the west shore of Lake Winnipeg and to provide construction, training, and service jobs.

The park is 90 miles north of Winnipeg on Hecla Island in Lake Winnipeg. A small campsite existed prior to park development, and development of hotel facilities has occurred after the study period. Hecla Provincial Park will serve an existing and increasing recreational demand for day trips, sightseeing, camping, and cottage facilities. Recreation's share of the development expenditure in the Interlake Area rural development plan (1967–77) approximates $4 million or 5% of the total budget of $85 million. During 1968–77, the outdoor recreation development program at Hecla Provincial Park (including provincial expenditures in addition to the development plan) involved the following expenditures: (*a*) $5.1 million capital construction, (*b*) $0.7 million manpower training corps, and (*c*) $2.6 million operations and maintenance. Land acquisition expenditures analyzed by Friesen are not included.

Data on capital expenditures, operations and maintenance expenditures, and wage and salary payments and training allowances obtained from analysis of government records were used to estimate consumption expenditures. The projected sectoral allocation of expenditures by visitors to Hecla Provincial Park was obtained through a visitor survey of 626 day-users and 415 camping parties conducted at the park during the summer of 1975 (Brown, Lyon, and MacMillan). Nonresponse tests and confidence intervals on day-use and camper average party expenditures indicate that data quality is not a problem.

The overall impact of the recreation program at Hecla Provincial Park in terms of the regional economy appears small, but the effects are much greater in some sectors than others. The largest impacts occur in the nonagricultural service sectors of the economy. The construction phase provides the bulk of the employment impact early in the project in the construction sector (92 man-years or 0.6% of projected employment of 15,729 in 1971), while at later stages government operations, maintenance expenditures, and visitor expenditures provide most employment in the government and service sectors (43 man-years or 0.3% of projected employment of 15,374 in 1976). Although the overall employment and income impact may appear low, much of the expenditure is concentrated in one municipality within the region (the rural municipality of Bifrost), which creates a significant local effect.[3]

The distributional effects of the primary output of outdoor recreation development are negligible. Over 77% of day-users and campers from Manitoba visiting Hecla Provincial Park in 1975 had 1974 family incomes in excess of $10,000. This is three times the proportion of Manitobans with individual 1974 incomes in this bracket (a group that contributed approximately 74% of individual tax revenue in the province) and suggests that the income class that receives the largest share of benefits from visiting the park pays the largest share of park costs (Brown).

The economic impacts in terms of income and employment generation also appear to have little effect on low-income groups and are concentrated in the urban sectors of the regional economy. The stable jobs that are created in Hecla Provincial Park tend to be in the higher income occupation categories, but the small number of seasonal jobs associated with visitor expenditures are in low-wage occupations. For instance, the average 1968 household income in Bifrost was $5,666 (Framingham, MacMillan, and Sandell), and those with occupations in the management, professional, laborer, and craftsman categories (the people employed in the Hecla project) had above-average incomes. The only tangible contribution of the recreation project to low-income families is the employment and training opportunities provided through the Canada manpower program in the construction phase.

An evaluation undertaken for agricultural development programs involving drainage (Norton and

[3] Subregional impact estimates are calculated using an input-output table (MacMillan and Lu). The rural municipality of Bifrost borders on the entrance to Hecla Provincial Park and contains the two towns nearest to the park, Riverton and Arborg. Because many of the personnel now employed at the park reside in the municipality, the impact of the creation of the park on this local economy is significant. The direct sales impact of the Hecla development program on the municipality is estimated to average $114,000 per annum over the construction phase of the program and $144,000 per annum over the operational phase. The majority of this impact derives from the local hiring of trucking firms during the construction phase and from local purchases and wage and salary payments during the operational phase. In total, the Hecla project is estimated to have generated average annual total sales in the municipality of $153,900, increased household income by $77,200, and provided employment for sixteen persons over the 1970–74 period. These annual impacts should increase to average $182,700 in sales, $163,500 in income, and employment for twenty-nine persons each year thereafter.

These impacts are significant in terms of the local economy. Although the effect on gross output is small (1.1% in 1976), the income and employment generated is more substantial. Income in the municipality is estimated at $5.36 million in 1976, to which the program will add $163,500 or 3.1%, concentrated in the government sector. Similarly, employment generation in 1976 of approximately twenty-nine persons adds 2.6% to the 1968 municipal employment level of 1,109.

MacMillan), land clearing (Pareek), and farm management training (MacMillan, Bernat, and Flagler) permits an assessment of the relative effectiveness of recreation versus other programs in achieving regional development objectives. Approximate capital costs for the Interlake Area drainage, land clearing, and farm management training programs were $6.8 million, $4.4 million, and $0.9 million, respectively (1968 dollars). The objective of the drainage program was to increase agricultural production by increasing the quality and quantity of agricultural land, and the capital expenditure over the 1968–73 period resulted in the reclamation of 123,885 acres, 75% of this being on livestock farms. The land clearing program was designed to stimulate the expansion of cultivated acreage in the Interlake Area by subsidizing clearing costs incurred by farmers. Over the 1967–73 period, 126,346 acres of land had been cleared, with an estimated 114,027 acres being in production in 1977. The farm management training program was specifically aimed at increasing the management skills of farmers in the Interlake Area through attendance at five-month courses. During 1967–73, 466 trainees graduated from the program, the majority being farmers having low gross receipts.

It is essential in any comparison of these programs that the capital and development phases of the program impacts be separated because it is not possible to sort out the short-term versus the long-term development implications for policy based on the aggregate results presented by Tung, MacMillan, and Framingham. Some types of program expenditures may have high initial regional impacts but minimal continuing effect on the local economy, and although average impacts may exceed those of an alternative program, the latter may well be preferable for reasons of capacity constraints in the economy and long-term stability. Average annual program impacts per million dollars of capital expenditure relative to regional economic development indicators are therefore shown in table 1 under two classifications—"capital phase" and "development phase."

Recreation impacts are below the impacts of agricultural programs in most categories, but the results clearly demonstrate that there is no single "best" program to achieve regional development policy objectives. Each type of resource development has its particular advantages depending on the priority assigned to target variables. For instance, drainage has the highest initial impact on household income, but farm management training has a larger ongoing effect. The latter also generates the largest impact on employment. Both the land clearing and outdoor recreation development programs appear to have relatively smaller impacts on the indicators listed than drainage or farm management training, but outdoor recreation has a larger impact than land clearing on nonagricultural household income and employment.

With respect to the longer term relative impacts (over a ten- and twenty-year horizon), a few preliminary observations can be made. If outdoor recreation visitor expenditures increase at an average of 10% per annum, the magnitude of impacts from this source will be fourfold the initial level in fifteen years. Conversely, drains in an agricultural program may well have silted up over a similar time span and drainage program impacts become negligible. Outdoor recreation impacts will, therefore, increase markedly over time, and while an evaluation of alternative programs over a five-year period may reject outdoor recreation as a means of achieving certain policy goals, the positions and rankings may be more comparable or even reversed if the evaluation were longer term. The results indicate the need for a critical assessment of long-term versus short-term recreation impacts.

The ongoing regional impact of outdoor recreation development programs arises from two components: operations and maintenance expenditure at the park and local expenditures by visitors to the park. In the two operational years of Hecla Provincial Park (1976 and 1977), the operational expenditures generate 74%, 94%, and 92% of the impacts in regional gross output, household income, and employment opportunities. This is because a large proportion of these expenditures are for salaried staff and wage earners, and these payments represent direct inputs into the household sector. Clearly, the proportion of impact attributable to operational expenditures will decline over time given that average visitor growth rates of approximately 10% per annum are exceeding projected annual increases in these expenditures. However, if operational expenditures grow at 5% per annum, it would not be until 1997 that the magnitude of regional impacts would be equally attributable to both operational expenditures and visitor expenditures.

A final critical factor in determining the magnitude of regional income and employment impacts generated by visitors to a newly established park is the substitutability between the park and other recreational sites in the region. The 1975 Hecla Provincial Park survey found that nearly 50% of the park visitors would have come to the Interlake Area even in the absence of the new park. Therefore, although the gross impact on the regional economy from expenditures by all visitors to the park may be significant, the net impact from the development of the new site will be much reduced. An extension of the analysis to include impacts associated with parks having alternative recreation activities would permit park planners to design parks consistent with development objectives (Craven, Framingham, and Capel).

Development Policy Implications

This study suggests that, with development such as is occurring with Hecla Provincial Park and the

Table 1. Average Annual Impacts of Resource Development Programs per $1 Million Capital Expenditure, Interlake Region, 1969–77 (1968 $)

Program and Economic Indicators	Average Annual Impacts per $1 Million Expenditure							
	Drainage[a]		Land Clearing[b]		Farm Management[c]		Outdoor Recreation[d]	
	Capital Phase 1969–73	Development Phase 1974–77	Capital Phase 1969–73	Development Phase 1974–77	Capital Phase 1969–73	Development Phase 1974–77	Capital Phase 1970–74	Development Phase 1975–77
Realized gross output ($1,000)	2,271.5	3,085.1	571.7	791.9	2,211.6	3,182.1	146.9	98.2
Agriculture[e]	1,482.0	2,087.4	296.6	548.4	1,392.5	2,100.7	8.8	6.1
Nonagriculture	789.5	997.7	275.1	243.5	819.1	1,081.2	138.1	92.0
Household income ($1,000)	557.7	763.8	129.3	197.8	531.7	778.4	59.4	57.9
Agriculture[e]	449.3	630.8	90.0	165.9	422.5	635.3	2.6	1.9
Nonagriculture	108.4	133.0	39.3	31.9	109.2	143.1	56.8	56.1
Employment (man-years)	153.8	137.2	42.8	55.5	185.8	215.8	15.7	11.0
Agriculture[e]	129.5	109.9	33.8	46.8	160.3	185.3	0.7	0.5
Nonagriculture	24.3	27.3	9.0	6.7	20.5	30.5	15.0	10.5
Government tax revenue ($1,000)	56.4	76.9	13.1	20.0	54.8	79.2	4.2	2.1
Agriculture[e]	43.0	60.0	8.5	15.8	40.5	60.7	0.3	0.2
Nonagriculture	13.4	16.9	4.6	4.1	14.3	18.5	3.8	1.9
Impact on low-income farms[f]								
Distribution of benefits (%)	36		70		87		0	

[a] Capital expenditure on the drainage program totaled $6.79 million during 1968–73, all incurred by the government.

[b] Capital expenditure on the land clearing program totaled $4.39 million during 1967–73, of which $0.707 million was government expenditure and $3.68 million was clearing costs incurred by farmers.

[c] Costs of the farm management training program totaled $0.88 million of government expenditure during 1967–73.

[d] Capital costs of the outdoor recreation development program at Hecla Provincial Park totaled $4.413 million of government expenditure during 1968–75. The majority of this was incurred over the 1970–74 period, the park opening in 1975.

[e] "Agriculture" is defined as sectors 1 to 2 for the drainage, land clearing, and farm management programs and sectors 1 to 3 for the outdoor recreation program. The difference in classification has negligible effect on the analysis.

[f] Percentage of drainage benefits to farms under $10,000 gross receipts is calculated by Norton and MacMillan, of farmers participating in the land clearing program with gross receipts under $10,000 by Pareek, and of farm management trainees with gross receipts under $10,000 by MacMillan, Bernat, and Flagler. The impact of outdoor recreation on low-income farmers is negligible (Brown).

Interlake Area, the majority of impacts generated are tied to local park service centers and, given that capital constraints exist, the overall regional effects may not be as significant in terms of achieving income and employment policy goals as investment in certain types of agricultural resource programs. On efficiency grounds, therefore, expansion of the existing agricultural base of the region may yield a higher payoff than developing an extensive cottage development in a provincial outdoor recreation park. In these circumstances, recreation development may only generate significant localized effects.

The potential regional impacts of recreation development can be assessed relative to the achievement of the largest possible increase in the elements of a regional final demand vector. In the construction phase, the effects on final demand will be greater if more local people can be involved in construction and operation and if training is emphasized. Recreation sites can attract more additional visitors and expenditures to a region if care is exercised not to duplicate existing recreational opportunities. Regional impacts will increase if local businesses add services to meet the needs of visitors and facilities are designed to increase stay length of visitors.

The results indicate that recreation program impacts score below agricultural programs with respect to most indicators of regional development (output, employment, income, government revenue, and income distribution). Careful investigation of the long-term versus short-term impacts is required because the benefits of recreation increase over the long term relative to agricultural programs. The present analysis is limited with respect to assessing long-term impacts by the use of 1968 coefficients for the nonagricultural sectors; adjustments are not made for relative price changes, and the park development is continuing with the addition of a hotel-motel complex. Additional research to overcome such problems is required to facilitate policy decisions with respect to the emphasis on recreation in regional development planning.

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Farm-Value Assessment as a Means for Reducing Premature and Excessive Agricultural Disinvestment in Urban Fringes

Howard E. Conklin and William G. Lesher

The possibility that farm-value assessments can prevent the spread of urban uses to farmland has been discussed at great length and answered in the negative (Barlowe and Alter; Council on Environmental Quality; Gloudemans; Gustafson and Wallace; Hady and Sibold; Schwartz, Hansen, and Foin). Real estate taxes cannot be reduced enough to assure that farmers will refuse to accept high urban offers for their land. Even the complete elimination of farm real estate taxes probably could not make farming that attractive.

This note considers only the possibility that farm-value assessments can help to prevent premature and excessive disinvestments in agriculture in urban fringes—prevent the discontinuance or debilitation of agriculture before urban users are willing to make high urban offers for all of the farmland in an area. It is argued that the usual process for allocating taxes in urban fringes discourages the continuance of agriculture wherever efficient farming requires large real estate improvements that must be maintained and occasionally replaced but lack value for nonfarm purposes. Evidence from two New York City urban fringe counties is used in support of this argument.

Nature of Urban Fringes

Urban fringes are considered to be the usually broad belts that extend outward beyond the closely settled suburbs of a city to the residential limits of the commuting population. There normally is an urban gradient within the fringe, with population densities, land prices, land taxes, and levels of public services higher near the suburban boundary (Bryant 1975b). In a growing metropolitan area, the frequency of conversions from open to urban uses also is higher near the inner edge of the fringe. There is no necessary relationship, however, between the width of the fringe and the area that will be newly occupied by close settlement within any specified time. In fact, fringes normally exist around U.S. cities whether they are growing or not.

Growth uncertainties have existed for long periods within most fringes. The fringes of most cities have been so large for many years that even under the patterns of population growth and distribution of the past three decades no one could realistically forecast their total incorporation into the adjacent densely populated urban complex in less than a matter of decades.[1] It has long been meaningful in the fringes to ask which areas are likely to experience the most growth and which individual parcels actually will be turned to urban uses in the near future, and it has been very difficult to provide reliable answers. Most population projections made a few years ago for fringe areas have proved to be wide of the mark. Speculators make a business of trying to anticipate what the market will do. If answers were easily arrived at, there would be no speculators.

Given these uncertainties, there have been marked tendencies to be overly optimistic in periods of growth. Real estate "booms" are well known. They are a special kind of mass psychological phenomena that feed upon a lack of full knowledge. They may be followed by "busts" that are corresponding phenomena in reverse.

It is possible to imagine that farmers in the fringe stand only to gain from the developments taking place about them. One might think that farm owners could continue to use their land as before until the day when they are offered a high urban price, or, if the city ceases to grow, they could continue indefinitely as before.

Such a picture could be realistic if the new uses that scatter increasingly among the farmers brought no adverse externalities and if farming involved no long-term investments that are immobile and of no value to urban purchasers. In some cases, the externalities could be avoided if the farmers *en masse* refused to sell any land until the urban market is prepared to purchase a large area. This, however, presupposes a larger measure of concerted action than normally is feasible. In many cases, also, farm and nonfarm lands are intermingled, so group ac-

Howard E. Conklin is a professor of agricultural economics, Cornell University, and William G. Lesher is a legislative assistant with Senator Lugar, Washington, D.C.

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[1] Since the area of a circle varies as the square of its radius, the fringe around the closely settled center of a metropolitan unit easily can exceed the area of the closely settled part by several times.

tion would need to extend beyond the farm community.

Most commonly, the externalities are not avoided. Stealing and vandalism increase; ordinances and informal pressures restrict farming practices; more services are demanded than farmers need, yet the costs they occasion often fall heavily on farmers; and the urban sale prices of some parcels provide the basis for assessment increases on all farmlands that further shift service costs to farmers.

In a few areas of the nation, farmland can be used successfully in its natural state. In most areas, however, it must be drained, leveled, or fenced; it must have buildings, irrigation facilities, or orchards added to it; and these investments not only must be maintained but occasionally replaced and almost never have appreciable value for urban purposes.

Farmers who own land in the urban fringe that will not produce efficiently without long-term improvements find the uncertainties of the fringe upsetting (Bryant 1975a). Throughout the fringe, any given parcel possibly can be sold soon for a high price relative to its farm value, but it is very difficult to predict which owners actually will have the opportunity to sell. The likelihood that neighboring sales will bring newcomers who introduce adverse externalities also must be weighed when a farmer contemplates a large new real estate improvement or major maintenance on an old one (Conklin and Dymsza).

Farmers often contribute importantly to the large rise in fringe land prices. Most are aware that to sell small plots or frontage modifies the usefulness of the remainder for farming, partly for reasons of reduced farm business scale but mostly due to the adverse externalities that flow from adjacent nonfarm settlement. Also, farmers considering the sale of their entire unit are aware that it is expensive and time consuming to relocate a farm business (Conklin). Farmers therefore ask a high price for their land until they and their family are through using it.

Some people, not understanding the constraints under which farmers operate, brand them speculators or opportunists. Others more dispassionately argue simply that, if farmers ask $5,000 for an acre of land when a commuting urban worker tries to buy it, farmland should be assessed for tax purposes at $5,000.

Many assessors in the past, being aware of the uncertainties in the fringe and the constraints on farming, assessed farms at urban values only after the farmers actually sold some portions of them at such prices. Some complain that this policy lets farmers who own valuable land go "free" if they sell all of it at one time. The point of view reflected in this complaint is bringing legislated revisions in assessment procedures. Some court decisions appear also to be guided by the same point of view.

The New York State Assessment Improvement Law of 1970 is an example of the new legislation (Lutz). This law placed the State Board of Equalization and Assessment in a stronger position to guide assessment policies, even though assessors still are local officials, and related subsequent action provided the means for computerizing the adjustment of assessed values. In both of these activities, strong emphasis is placed upon current sale prices. In effect, this law accedes to the argument that, if farmers ask a high price for land when nonfarmers wish to buy it, it should be assessed at a high price. Though farmers place a high price on their land because they are reluctant to sell due to nonfarmer-caused externalities and the costs of reestablishment, at least a few nonfarmers actually pay the price, even in the outlying areas of the fringe. These sales are then accepted as setting market prices for farmland assessment throughout the taxing jurisdiction.

The Orange County Experience

The 1974 reassessment of properties in Orange County, in the lower Hudson Valley about 60 miles from Manhattan, is an example of the consequences of the New York Assessment Improvement Law. The reappraisal in Orange County was done by a private firm, but they followed the guidelines suggested to assessors by the State Board of Equalization and Assessment. The task was undertaken at a time of high real estate activity, so numerous instances were at hand in which speculators, developers, or commuters themselves had paid the farmer's asking price.

Orange County's reappraisal put values of $1,000 to $2,000 per acre on most of the dairy farms in the county. These are farms of quite modest productivity, and comparable units were then selling for $300 to $400 per acre elsewhere in the state. Taxes would have risen sharply as a result of the reappraisal, approaching a total of $50 per acre on dairy farms had it not been possible to obtain farm-value assessments.

Farm-value assessments are provided for in New York by the agricultural district law passed in 1971 (Lesher and Conklin). This law permits the formation of agricultural districts through landowner initiative. Once a district is formed, six measures to facilitate farming and discourage nonfarm development are brought into play, one of these being farm-value assessments.[2] Farmers in districts may

[2] The agricultural district law, within the districts, also limits ordinances affecting agriculture, instructs state agencies to encourage farming, modifies eminent domain proceedings, restricts public funds to facilitate nonfarm development, and limits special service tax assessments on farmland (Conklin and Bryant). Farmers outside districts may obtain farm-value assessments by signing commitments for eight years (renewed annually), but conversion to a nonfarm use then involves a monetary penalty equal to twice the amount of taxes levied on the entire property for the year following breach of the commitment. In general, farmers consider

have the value of their land in excess of its value for farming exempt from taxation if they produce an annual average of $10,000 in farm products and file an annual application. Land that has received this exemption is subject to a maximum five-year rollback if converted to a nonfarm use. As soon as the probable results of the reappraisal became clear, agricultural districts began to be formed in all farming areas of Orange County, and farmers asked for farm-value assessments.

In-depth interviews of fifty-four full-time commercial farmers in Orange County were conducted in two studies made in 1975, shortly after the revised assessment rolls became official and the majority of the agricultural districts had been completed (Hunt, King). Farmers had been very much surprised and greatly distressed by the large tax increases that the new assessments would have imposed on them. For some, the proposed increases more than equaled their net farm incomes. They were much less optimistic about opportunities to sell their lands at urban prices than were local government officials and real estate agents. Young men, many of whom were heavily in debt, were the most disturbed.

While the agricultural district law was passed earlier, the farmers of Orange County had not planned action under it prior to the reassessment. The intent of the law is that an agricultural district increase a farmer's chances for staying in farming but reduce his chances for a nonfarm sale, and farmers seemed aware of this. Farmers earlier were not under serious urban pressure and saw no reason for action that would reduce their chances to make an urban sale even though these were not high.

With the reassessment, however, many farmers saw little possibility for financial survival even in the short run, and all would have been unable and/or unwilling to invest in long-run real estate capital maintenance or replacement.

Traditional economic theory accepts the possibility under these circumstances that the farmers currently operating in Orange County might fail financially due to high taxes and be eliminated from farming. This theory holds, however, that if farming remains the highest net income producing use, the value of the land will be lowered to compensate for the higher taxes and other farmers will take over the farm units (Stocker). Actually, a devaluation of the magnitude needed to compensate for the tax increases that would have resulted from the Orange County assessment reappraisal would involve many foreclosures. Those foreclosed on would henceforth be considered poor risks, and few are available with the needed skills and capital to replace them. Nonfarm employment is relatively plentiful in fringe areas, making farming somewhat less attractive by comparison. Bankers, having lost money on one round of foreclosures, would be very reluctant to loan on farm businesses again. The interruption in farming occasioned by the foreclosures would in turn interrupt agribusiness activities, and some of these would fail financially. The total agricultural industry would have been sufficiently disrupted for many years to destroy it in at least parts of the country.

If the rates of urban growth still prevailed that marked northeastern cities for thirty years after World War II, such agricultural disruption would merely occasion a premature death for the agricultural industry. After a few years of idleness, the land would be turned to urban uses. Today, conditions are different.

Since the reappraisal, the real estate market has weakened in Orange County. Many factors have contributed, including the national recession, the special economic difficulties experienced in New York, and, most importantly, the sharp decline in metropolitan growth in this region of the country. No major revisions have been made, however, in assessed values on any types of rural land in Orange County. Local officials and real estate interests still argue strongly for expecting renewed growth in the county, and some bitterness is expressed about how farmers were permitted to get their tax increases rolled back.

It is difficult, of course, to predict levels of future development in Orange County. It seems clear from the interviews that without farm-value assessments some farm businesses would have already been discontinued under conditions in which the land would not have been put to another use but only held by a speculator who bought it cheaply. Capital improvements on farms would be deteriorating, and more farm businesses would be discontinued soon.

It is the judgment of the authors that it will be many years before New York again experiences strong levels of metropolitan growth. The 1974 reassessment in Orange County was based on false anticipations, but it has become largely institutionalized and can be counteracted only by equally institutionalized arrangements—farm-value assessments.

The Suffolk County Experience

It is useful in attempting to see the Orange County experience in perspective to look at parallel developments on the opposite side of New York City. Suffolk County on Long Island has attracted much attention by its program for purchasing development rights on farmland. That program was several years in the making and finally materialized in a more limited form than originally planned. During this interval, interest in agricultural districts was low, but it is now growing.

A few of the differences between Suffolk and Orange counties are pertinent. (*a*) The population

the commitments less desirable than the farm-value assessments provided for in the districts.

of Suffolk County has grown much more rapidly. (*b*) Suffolk County is as far from downtown New York, but close suburban settlement associated with the city has extended into western Suffolk County while separated from Orange County by the highlands of the Hudson. (*c*) Suffolk farmers produce a higher value of farm products on less land. (*d*) There has been no comprehensive reappraisal of property in Suffolk County, and much farmland is assessed on its farm value. A recent court decision, known as the Hellerstein decision, has directed assessors in the Town of Islip, Suffolk County, to assess on the basis of "full market value" (Lesher). This is being interpreted as requiring the type of reappraisal conducted earlier in Orange County. Similar cases are pending in other towns.

Discussions of a possible development rights purchase program were begun in Suffolk County some five years ago, and provision was made for such a program in the 1974–77 capital budget (Newton, Scholvinck). Farmland owners were invited to submit bids for the sale of rights in 1975, and 381 of them indicated a clear interest in such sales on 17,000 acres (Bryant and Conklin). Twenty-one million dollars have now been appropriated. This money is expected to buy rights on about 4,000 acres, less than 10% of Suffolk County's 55,000 acres of farmland. It appears unlikely that additional money will be available for several years, if then.

Suffolk farmers expressed little interest in agricultural districts until the size of the development rights purchase program was determined because development rights purchase automatically keeps farm taxes at farm-value levels. Also, strong pressure has developed only recently for reassessment. Chances for nonfarm sales have been generally good in the county, and farmers were not willing to reduce them by forming districts so long as the advantages of districts would be small. (Farmers who anticipated possible sale of development rights spoke favorably of forming districts after the sale in order to gain the nontax benefits of districts, and some of the few who will be able to sell now plan to participate in district formation.)

The current certainty of reassessments in the county combined with the finalizing of the development rights purchase program are now stimulating interest in agricultural districts, and some districts are in process of formation. Many farmers in Suffolk County say they would be forced to discontinue farming if they were assessed for development rights.[3] These are especially the younger farmers who would have cash-flow problems. If they could retain their development rights with no limitations, they might find it profitable in the long run because the chances for a good nonfarm sale in ten to twenty years appear high. Even in Suffolk County, however, these chances are not 100%, and short-run chances are much lower (Lesher and Eiler). Moreover, agricultural credit agencies are reluctant to loan on the value of development rights.

Suffolk County thus is following a path similar to Orange County, though more slowly, due to the emergence of the development rights purchase program and the deferral of reassessment. Farmers in both counties are resorting to farm-value assessments when tax pressures become very high and are expecting them to permit their survival.

Conclusions

In two important agricultural counties of the New York metropolitan fringe, farm taxes, when added to the other adverse externalities created by scattering nonfarmers, threaten to discourage farmers from making the real estate improvements needed to remain efficient up to the time when urban users actually are ready to pay acceptable prices for the land and convert it to urban uses. In the first instance, agricultural districts have been formed, permitting farm-value assessments and reducing the other externalities. District formation is starting in the second instance. Farmers in districts appear optimistic enough to renew aggressive investment policies.[4]

Although there is a continuing urban demand for some farmland in both counties, most farmers within the fringe appear to realize that not all of them can sell at urban values possibly for decades. With no assurance of an immediate nonfarm sale and faced with escalating real estate taxes, farmers have opted for farm-value assessments through the formation of agricultural districts. Apparently, farmers feel that in taking this step they are trading a reduction in their chances for a nonfarm sale for increased security in farming (urban uses will go more frequently to the intermingled nonfarm lands) but consider the trade worthwhile. Farmers know they need to invest continuously in real estate improvements to remain competitive but also realize that to do so means a long-term commitment to farming. Thus, faced with the conditions of the fringe, farmers by choice have elected to operate in an environment where agricultural production is encouraged. There they can continue to produce efficiently until urban pressure becomes great enough to bring them an offer that will cover their fixed investments and the costs of moving or of changing occupation.

The developments that have produced high farm taxes in the New York City fringe probably are not

[3] Recent appraisals of total farmland market values have averaged about $5,000 per acre in several parts of the county, $1,500 of which is considered farm value. Taxes presently average about $75 per acre of farmland but could reach levels above $200 as a result of reassessment (Lesher and Eiler).

[4] No quantitative measurements of farmers' investment reactions have been made under these circumstances, but Nelson Bills (USDA, ERS, NRED, stationed at Cornell University) is undertaking such a study in western New York.

unique. While research repeatedly has concluded that farm taxes cannot be low enough to stop urban expansion, it is proposed here, with some evidence, that they can be high enough to destroy or debilitate agriculture far ahead of the advancing urban perimeter. If this proposition is correct, farm-value assessment can be an important public policy instrument even if it cannot create a fence around urban growth.

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Developing a Competency-Based Curriculum in Agricultural Economics

Loys L. Mather, Joe T. Davis, Russell H. Brannon, A. Frank Bordeaux, Jr., and Robert L. Beck

In an article in this *Journal*, Manderscheid sets forth several guidelines for curricular changes (pp. 745–46). He suggests that curriculum change is a dynamic process requiring efforts to monitor developments both within the discipline and in supporting and complementary disciplines and notes the need for integration of individually planned instructional activities into a systematic whole. Manderscheid further hypothesizes that an inadequate humanities component, insufficient attention to the needs of students planning for a career in the public sector, and a tendency to base courses and curricula on teaching objectives rather than learning objectives all constitute weaknesses in current agricultural economics curricula. Manderscheid's work has exerted considerable influence on the direction taken in a recent review and restructuring at Kentucky. While much remains to be done in terms of implementation, the procedures followed may provide useful guidelines to other institutions contemplating similar curricular revision.

This paper reports on the process employed in developing a competency-based undergraduate curriculum in the Department of Agricultural Economics, University of Kentucky. While applying competency-based instructional techniques to academic programs in higher education is not new, this approach has received very limited use in our profession as well as in colleges of agriculture generally. A competency-based core curriculum has been developed in the College of Agriculture, University of Arizona (Zubrick).

Basically, a competency-based curriculum is an attempt to identify desired outcomes of an educational process (vis-à-vis experiences) and to certify these on the basis of demonstrated behavior (O'Connell and Moomaw).[1] The program being developed at the University of Kentucky is not strictly a competency-based program, since it will not be centered around individual, self-paced courses. It is competency-oriented, however, in that learning objectives were developed on a competency basis for formal classroom courses. Multimedia learning objectives are being developed to supplement rather than substitute for the classroom. The department chose this approach because it was felt that greater weight should be given to students' learning needs and objectives as opposed to faculty teaching interests and objectives.

The movement towards a competency-based approach was also influenced by recognition of the fact that higher education is entering an era of greater accountability. Funding sources, especially state legislatures, are likely increasingly to evaluate institutions of higher education in terms of their ability to produce a product that is employable, socially useful, and productive. In addition, students are demanding more a priori information on what they can expect "to learn" from a course or program of study and what applications can be made of their training programs. This latter demand requires clearer statements of course objectives and material to be covered, as well as improved systems of communication through advisors, student professional clubs, and printed materials in the office of the dean of undergraduate studies.

A competency-based curriculum requires an integrated instructional program, and our program was weak in this regard. Individual courses had been added over the years with little attention to appraising their relationship with other courses, to the total curriculum, or to educational needs. Additionally, the College of Agriculture has recently adopted a new curriculum permitting departments increased flexibility in curricula and program option development.

Finally, several external developments that affect the market for graduates and the currency of curricula have become apparent. These include (*a*) the phenomenal expansion of world marketing and trade that agriculture has experienced in recent years and the resultant demand, supply, and price implications; (*b*) structural changes in farming, agricultural industries, and rural America; (*c*) an increased concern over environmental issues and al-

Loys L. Mather, Robert L. Beck, and A. Frank Bordeaux, Jr., are associate professors, Joe T. Davis is an assistant professor, and Russell H. Brannon is professor of agricultural economics, University of Kentucky.

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[1] Most adaptations of competency-based programs in higher education have involved developing self-paced, multimedia courses as substitutes for the formal classroom presentations. As students satisfy the requirements of a given learning level, they move up to the next level of learning activities encompassed in another self-paced course.

location and utilization of finite natural resources; (*d*) the apparent lack of real understanding of agriculture by the general public and by decision makers—especially those in a position to influence agricultural and rural policy; (*e*) reduced percentages of students in colleges of agriculture who come from farm backgrounds; and (*f*) an increased activism in areas of consumer interests. These factors imply changes regarding the nature of demand for agricultural economics graduates and the types of training that they should receive. They also have implications for the service role of an agricultural economics department in the total university.

Procedures

Developing a competency-based curriculum represented a significant change in direction, and the faculty recognized at the outset the need for a comprehensive review of the entire undergraduate program. It was agreed that the review would proceed as if a totally new program were being developed, rather than designing a program around existing courses, program options, and resources. Any course retained in the new program would have to be justified on the basis of need rather than prior existence.

Overall responsibility for the review was vested in the department's Undergraduate Program Committee, composed of five faculty members and one student representative. While maintaining overall control and responsibility, the committee assigned tasks to three subcommittees representing marketing and agribusiness, farm management and production economics, and natural resources and rural development. Several factors prompted identification of these three subcommittees. Foremost was the fact that student interests tend to fall within these areas. Nearly all faculty members (research, teaching, and extension) were assigned to and involved in the work of one of these subcommittees. This "grass roots" involvement of the faculty appears to have been a critical factor in subsequent acceptance of the revised program by the department.

In order to profit from the experiences in undergraduate program development on other campuses, visits were made to four agricultural economics departments. An effort was made to develop an understanding of the structure, philosophy, and orientation of these programs and to derive useful insights and ideas that might be incorporated into the Kentucky program. The four departments to be visited were selected on the basis of several criteria, including size and recent change in size of undergraduate program, recent program reorientations of significance, and emphasis devoted to undergraduate training. An attempt was also made to achieve some regional diversity.[2]

In addition to visits to other campuses, broader insights into the structure of undergraduate education in the United States and Canada were obtained through a mail survey of agricultural economics departments in nearly eighty public institutions of higher education.[3] Responses to this questionnaire provided information regarding program options being implemented around the country and anticipated major growth areas in terms of student enrollment, kinds of employment opportunities available to recent graduates, numbers of students from nonfarm backgrounds, advising systems and approaches to evaluating advising and teaching assistants, and administrative support of undergraduate programs. This information proved quite useful in subsequent structuring of the new program.

A very critical and time-consuming step in the developmental phase consisted of identifying and preparing a set of learnings, competencies, and skills needed by graduates, which would serve as the basis for subsequent identification of courses needed in the curriculum. This phase involved obtaining information and ideas from several different groups.

Employers were surveyed regarding job titles, descriptions, duties, and overall training needs of agricultural economics graduates who they hire. Guidance was specifically sought in identifying those areas of training in which graduates are typically adequately prepared and those usually found to be lacking. Recent graduates were also surveyed in a similar context. Based upon their job experiences, graduates were asked to identify areas of academic training that should have been provided but that were inadequately treated.

Involvement of employers and former students provided a very useful information source and one that the department hopes to continue to utilize. As Butz has stated, "Too often . . . professors, department heads, or others assume that they know best what should be in the curriculum and how it should be presented, without bothering to research the market. . . . I believe that most agribusiness economists and executives would be willing to advise on training needs if they were asked to do so" (p. 467). In a similar vein, French has indicated the need for university and agribusiness representatives to get together on training and recruiting (p. 465).

Based upon information from the previously noted sources, descriptions of student learning needs were developed by each subcommittee. These areas of learning were then assessed to determine whether the training could be provided within the department or would require reliance on other departments. For those learnings that fell

[2] Visits were made to Cornell University, Michigan State University, North Dakota State University, and Oklahoma State University.

[3] Usable responses were received from forty-nine institutions including thirty-nine 1862 land grant universities, two 1890 land grant universities, three non-land grant institutions, and four Canadian universities.

within the department's area of teaching responsibility, potential courses were identified by grouping learnings that could logically be provided within a given course. Topical outlines and broad course objectives were then prepared. In areas requiring that learnings be provided by other departments, existing courses were assessed and where necessary new course proposals were discussed or developed in cooperation with relevant departments.

The next step, identification of potential program options within the agricultural economics major, was strongly influenced by the surveys and discussions with employers and by other information gathered by the department. Program options were defined with sufficient specificity to reflect meaningful categories of jobs, yet were broad enough to permit the student some alternative employment opportunities across options. Courses considered essential to provide the needed training were specified under each option.

Upon completion of the initial set of course proposals and program options, a draft reflecting the proposed structure of the undergraduate curriculum was developed. This was presented for critique both in written form and orally to the department faculty, other departments on campus that might be affected by the revision, employers, and former and current students. In addition, three agricultural economists from other institutions were invited to spend two days on the campus for the purpose of meeting with the committee and later with the department faculty to critique the proposed program.[4]

Concurrent with the critique of the proposed curriculum, the committee undertook to reconcile the optimal model of courses and program options with immediate and long-run resource availabilities. This entailed determining availability of faculty to staff the proposed set of courses, assessing the extent to which other departments would cooperate in course changes, and estimating space and equipment availabilities. In those cases where more courses were proposed in an area than could be provided by existing faculty resources, it was first determined which courses could be combined, while still meeting learning needs. Where combination was not feasible, an effort was made to establish priorities for courses and learnings and thus to determine which learnings must remain unmet due to current resource limitations.

Information gained during critique of the initial draft of proposals, plus results of efforts to adjust the optimal model to available resources, served as major inputs into the preparation of a second draft. This draft was then presented to the department faculty. Ensuing discussion, coupled with information solicited from individual faculty members regarding courses that they would be interested in teaching, permitted the faculty to approve the new program with full knowledge of likely demands on their time. Approval was granted with the understanding that not all facets of the curriculum would be implemented immediately but that approval was being given to a long-range planning model for the department's undergraduate curriculum.

Following approval by the departmental faculty, the revised program required approval by the college and university. This process was facilitated by the support provided to the review by administrators at all levels in the university. Without this, the approval process would likely have been a much more laborious procedure. Ultimate approval was also more easily obtained because of the numerous contacts established with other departments and colleges within the university throughout the review process. Most potential conflicts concerning specific courses, subject matter areas, and proprietary interests in addressing particular subject matter were resolved prior to formal submission for approval. Departments likely to be affected by changes in the agricultural economics program had an opportunity to express their views during the formative stages.

Implementation Phase

Several steps have been identified as essential to implementation of the revised curriculum. The initial step was to organize a faculty workshop (conducted by an external resource person) to provide training in writing and using competency-based learning objectives.[5] This workshop served as the basis for subsequently developing specific learning objectives and course content. Committees of two to three persons have been assigned to develop each course, with the eventual course instructor likely to be one of these committee members. This constitutes the most intensive and critical phase in the curriculum revision, since it is the implementing link between the desired and the realized curriculum. Utilizing the broad course objectives and topical outlines developed for each proposed course as a starting point, major subject areas or learning units within the topical outline are being identified. Within each unit, statements of competency-based learning objectives are developed along with an estimated amount of time to be spent on the unit, prerequisite material necessary for that unit, and identification and preliminary development of instructional and learning activities

[4] The three outside reviewers were Dale C. Dahl, professor of agricultural economics, University of Minnesota; Carroll V. Hess, dean of agriculture, Kansas State University; and R. J. Hildreth, managing director, Farm Foundation. Each reviewer received a full set of documents concerning the review in advance of his arrival on campus, and each subsequently prepared and sent to the Undergraduate Committee a detailed set of written comments following the campus visit.

[5] Frank Colton, director of the University of Kentucky's Continuing Education Center, conducted an all-day workshop devoted primarily to the development of course outlines utilizing the behavioral (competency-based) objective approach. Film strips, worksheets, and other materials were furnished. Over 90% of the department faculty participated in the entire workshop.

including assigned reading, field trips, audiovisual software, papers, reports, exercises, etc.

Course committees have also been assigned the task of identifying topics or units within courses that will require supplementary learning aids. A part of the department's long-range plan is to develop, in conjunction with the college, a multimedia learning resource center. Such a center can serve a variety of purposes. One such function could be to provide out-of-class remedial work for less adequately prepared students, or additional review for those desiring it, without slowing down the formal classroom pace. Reliance would be placed upon slide-tape presentations, audiovisual cassettes, computer-assisted learning, etc., located in the learning resource center.

Another major step in implementation is the design of an appropriate structure for providing closer monitoring of the undergraduate program. A position of Director of Undergraduate Studies is being established to assist the department chairman in coordinating the undergraduate program. The incumbent will also serve as chairman of the Undergraduate Program Committee and will have major responsibility for developing a means of continuous review and evaluation of the curriculum. This will likely require periodic review and revision of the learnings and competencies needed by graduates, as well as revisions in course content and program requirements as learning needs change. Additional areas needing attention include development of a system to maintain contact with employers and former students, coordinating the department's student advising efforts, and supervising recruitment of potential students.

New Features in the Curriculum

Several new features of the revised curriculum are noteworthy. The department now has a long-run plan for its undergraduate program. While various facets will be implemented in phases, a specific direction has been taken and a commitment has been made. The importance of a strong undergraduate program has been established and accepted by the department faculty.

Prior to the restructuring of the college curriculum, every agricultural student, regardless of departmental major, satisfied the requirements in one of three curricula: technology, science, or business. Under the revised college and departmental program, a student majoring in agricultural economics specifies an option within the department. In the area of agricultural marketing and management, students can choose from among agribusiness management, agricultural financial and credit management, and farm management. In the area of natural resources and rural economic development, options are provided in natural resource and environmental economics and in rural economic development. While there will naturally be a number of courses that will be common to all options, there is sufficient diversity to provide a differentiated product. This differentiation will be accentuated by supporting courses outside of the department.

The revised curriculum represents a reorientation in thrust in some learning areas. Greater emphasis will be devoted to economic principles, methodologies and their application (linear programming, computer science, etc.), and to oral and written communications. In some other areas, such as agricultural commodities, emphasis will be redirected to provide greater flexibility, depending on student interests. Appropriate sequencing of the entire set of undergraduate offerings has been developed along with identification and enforcement of prerequisites for each course.

As a result of developing the set of learnings and grouping related learnings into courses, several courses evolved that will require less time than the traditional three-credit course to cover the material. This has led to identification, in several areas, of basic material to be covered in three-credit courses, with the option for taking follow-up application courses in a variety of one-credit modules. These one-credit modules will be organized and taught in the same way as a three-credit course but for only one-third of the semester. In a given semester, a student may choose from among a number of modules to be taken at various times throughout the semester. One-credit modules will be offered in marketing agricultural commodities, farm and agribusiness management topics, data processing, linear programming, and agricultural credit institutions.

The department has developed improved communications with other departments in the college, and this has enhanced understanding and appreciation of the potential service role in providing applied economic content to their programs. To help meet outside needs, a minor in agricultural economics is being established and will be one of only two minors currently offered in the university. Employer discussions and surveys indicate that agribusiness recruits from among two major categories of agricultural graduates. One group comprises those potential employees whose primary training is in agricultural economics and agribusiness, with training in technical agriculture being of secondary importance. There is a sizable demand, however, for graduates with primary training in technical agriculture who have some competence in agricultural economics or agribusiness. The agricultural economics minor addresses this latter category. In addition to the minor, more courses in the department will likely provide a service component than was the case under the previous curriculum.

The revised curriculum will give greater emphasis to both oral and written communications, a requirement that was dropped from the college curriculum a few years ago. Surveys of employers

show that this is the greatest weakness among graduating students. In reinstating the requirement, a flexible approach is to be followed, with students being required to take courses in the area at levels appropriate to upgrading their existing competencies. One or two courses in communications obviously will not bring all students to a satisfactory level of competence, and it is recognized that instruction within the array of departmental offerings must also stress the improvement of written and oral communication skills. Individual instructors must be encouraged to devote greater emphasis to this dimension.

Preliminary Assessment

While assessment of the revised curriculum is premature, some observations on the procedures followed are appropriate. (*a*) The initial decision to proceed as if the department were designing a totally new program constituted an essential and critical step in insuring faculty involvement in the process and also in creating a faculty awareness that significant change was under way. (*b*) Developing the list of learnings and competencies needed by graduates, while time consuming, was useful in identifying essential training areas and in minimizing repetition of material and course overlap.

(*c*) Visits to other agricultural economics departments were extremely helpful. Since visits were made early in the review process, it was possible to take advantage of numerous ideas, experiences, and philosophies in planning our curriculum revision. (*d*) The external review was a very valuable contribution. The three invited reviewers pointed out some previously unseen weaknesses. In other instances, they lent support to committee findings and recommendations and thus facilitated their acceptance by the faculty. Although some of the reviewers' suggestions were not implemented, many of these caused the faculty to reassess previous positions. Clearly, a much better product has evolved as a result of the outside review. (*e*) Discussions with other departments on campus were fruitful and would form an integral part were we starting the review anew. All parties appear to have derived better mutual understanding. Similar discussions should continue in the future, at least on a semiformal basis.

(*f*) Student involvement in the curriculum review contributed substantially to the final product. The student committee members provided a significant input in a tangible way by pointing out problems in department offerings and proposed offerings as well as in courses in supporting departments. Less tangibly, but equally important, their formal and informal discussions with other students formed an invaluable communication channel throughout the review process and in subsequent implementation efforts. (*g*) At this juncture, faculty commitment appears stronger than one might have anticipated, given the history in academic institutions of resistance to curriculum change. One manifestation of support is the expressed willingness to teach undergraduate courses. In recent years, about half of the faculty has been involved in teaching at the undergraduate level. Once the revised curriculum is implemented, roughly 85% have volunteered to teach undergraduate courses. (*h*) While members of the department have established contact with employers and former students in the past on an individual basis, previous efforts by the department were not coordinated. The recent experience has resulted in a heightened awareness of the important contributions that such contacts can make in a variety of ways. Strengthening of these contacts will be essential to efforts to maintain conversancy with changing needs in the market place and thus in departmental programs. (*i*) To successfully undertake a comprehensive curriculum review, the full support of appropriate university administrators is essential. Without this support, any such effort is almost surely destined to fail.

In the final analysis, the major faculty concern should be how well the educational program is equipping graduates for on-the-job performance and for assuring a personally satisfying and productive role in society. As higher education moves into a period of greater accountability, the type of person trained and his or her social and economic utility will be an important factor in the evaluation of our discipline. Thus, performance of graduates is a critical issue. Continued inquiry is needed into the success of programs in preparing students for the type of work they are expected to carry out and in equipping them with the necessary skills to advance within the system.

This department has concluded that a competency-based approach to curriculum development has much to offer. Such an approach is oriented towards those things that students should be able "to do" upon graduation rather than what they should "understand." Although much remains to be done, hopefully the steps taken in developing the Kentucky curriculum will help move our students' educational process in that direction.

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Undergraduate Programs in Agricultural Economics: Some Observations

Robert L. Beck, A. Frank Bordeaux, Jr., Joe T. Davis, Russell H. Brannon, and Loys L. Mather

In recent years, increased attention has been focused on undergraduate education in agricultural economics. The profession's interest in undergraduate education has been demonstrated through sponsoring workshops, the Distinguished Undergraduate Teacher Awards, and, more recently, program emphasis at the annual meetings. Periodic evaluation of courses and programs at the department level in many institutions suggests a continuing concern for quality undergraduate education.

As part of a comprehensive review of undergraduate agricultural economics programs at the University of Kentucky, a mail survey was conducted to obtain information relative to the current status and anticipated changes in programs in the United States and Canada.[1] Questionnaires were mailed to departments at land grant institutions in the United States and Canada in early 1975. Data obtained from forty-six departments are presented in this note. While the data requested touched on many facets of the undergraduate program, this note focuses primarily on the current size of agricultural economics programs, departmental characteristics and faculty involvement, and potential growth areas. As such the note offers some parallels to the Storey and Christensen survey of graduate programs previously reported in this *Journal* and elaborates on aspects of undergraduate programs discussed by Davis et al.

Undergraduate Enrollment

During the period under study (1970–75), enrollment in agricultural economics programs increased. For all regions in the United States and Canada, average departmental enrollment increased from 97 to 118 or 22% (table 1). The highest rate of increase (38%) occurred in the southern region. Although the largest departmental enrollments are still found in the North Central region, very little growth (7%) occurred during the study period.

As a profession we might view a 22% increase with a great deal of satisfaction. But, how have we fared relative to other disciplines? Their increases have largely paralleled increased enrollment in colleges of agriculture in the United States, which increased 39% from 1971–72 to 1974–75, while the average enrollment in agricultural economics increased only 20% during this period. While the relative rates of enrollments may be reason for some concern, it should be noted that this applies only to declared departmental majors. Agricultural economics departments may be performing a greater service role, and thus student contact hours may be increasing at a greater rate than enrollment.

With a declining farm population and increasing enrollment in colleges of agriculture, an increasing proportion of majors with nonfarm backgrounds is expected. Fifty-four percent of the departments indicated that more than half of their students came from farms. In the Northeast, all departments indicated that less than 50% of students had farm backgrounds, compared with the South and North Central, where 60% and 72% of the departments, respectively, reported that more than 50% of undergraduate majors come from farms.

The high percentage of students currently coming from nonfarm backgrounds introduces a new dimension into planning and implementation of undergraduate programs. Must we compensate by increasing requirements in applied biological science areas, particularly agronomy and animal science? Or, should we consider the employment opportunities for agricultural economics majors to be in sales, finance, management, etc., and thus emphasize accounting, business management, communication, etc.? Perhaps a flexible program that permits students to complete necessary training as agricultural economists but that also provides coursework in technical agriculture may substantially strengthen students' employment opportunities.

Student Advising

There is a general presumption that colleges of agriculture do a "better" job of advising students than do most other colleges. The survey data suggest that the student-faculty ratio is in most instances

Robert L. Beck, A. Frank Bordeaux, Jr., and Loys L. Mather are associate professors, Joe T. Davis is an assistant professor, and Russell H. Brannon is a professor of agricultural economics, University of Kentucky.

[1] Financial support for this review was furnished by the Southern Region Education Board. Detailed information on the survey and results is available from the authors.

Table 1. Average Enrollment in Agricultural Economics Departments by Region

Years	Northeast	South	North Central	West	Canada	All Regions
1970–71	105	73	175	74	24	97
1971–72	110	75	167	78	22	98
1972–73	116	85	157	73	34	99
1973–74	118	89	164	75	44	104
1974–75	130	101	188	86	48	118
Percentage increase	24	38	7	16	100	22

considerably lower in colleges of agriculture than in colleges such as arts and sciences. The apparent difference of orientation in colleges of agriculture towards students as individuals may be a function of this lower student-faculty ratio. If enrollment in colleges of agriculture continues to grow in the face of relatively lean budgets, some adjustments may be necessary in order to maintain the "outstanding" advising reputation.

From the survey it is apparent that approaches to carrying out the advising function vary from assigning a few faculty members to do all of the advising to spreading it among all faculty members. One-third of the respondents indicated that all of the advising was done by one to five advisors with advising loads ranging from two to fifty students and an average of fifteen students per faculty member. Only 20% of the departments indicated that some system of evaluating undergraduate advising was used. Thirty percent indicated that all faculty members were involved in advising students. When asked to reply to the question, "what is the average advising load for faculty members involved in undergraduate advising?", over one-half (63%) indicated nineteen or fewer advisees per advisor.

Program Options and Growth Areas

While economics may be a science of scarcity, no paucity of program options offered by agricultural economics departments was found. To the contrary, identifiable options indicate a range from the traditional farm management and marketing to very specialized programs such as veterinary business management. Although a wide variety of options was reported, a tendency to stay with the more traditional ones is evidenced by thirty-six departments offering a curriculum in agribusiness, twenty-five in general agricultural economics, eighteen in farm and ranch management, and seventeen in resource economics. This apparently reflects a tendency to hold on to traditional programs while expanding into new areas of emphasis. Unfortunately, data were not available to evaluate student demands for the specialized options.

In addition to current program options, respondents were asked to identify program options or anticipated areas of growth during the next five to ten years. The choices provided and responses received are in table 2. Not too surprising is the fact that almost two-thirds of the respondents (62%) identified agribusiness management as the program likely to experience the greatest growth in the near future (five to ten years). There was no way to determine the extent to which this response was influenced by the phenomenal growth in the program during the last decade. Suffice it to say that perhaps we have not exhausted the potential for expansion or growth in the area. We must continue to be "alert to the opportunities for developing new markets for our services both traditional and new . . ." (Nicholls, p. 970), lest we become a declining industry. This admonition continues to be timely and appropriate.

Preparing students for a wide variety of job opportunities requires breadth in a program option as

Table 2. Areas of Anticipated Growth in Undergraduate Enrollment in Agricultural Economics in the Next Decade

Areas of Undergraduate Instruction	Percentage of Responding Institutions Specifying Each Category			
	Greatest Growth Area	Second	Third	Fourth
Agribusiness management	62	19	13	4
Farm management/production economics	16	44	18	18
Natural resource economics	11	14	53	14
Rural development	7	17	13	50
Other	4	6	3	14
Total	100	100	100	100

well as the number of options offered. The function of any option is to provide guidance to the student in planning. Thus, there is need for innovative thinking on the part of faculty. The cost of offering additional options may be very minimal to the department. Benefits to the student may be great. Thus, benefit-cost may become a relevant criterion on which to base the decision of number and types of curricula to offer.

Summary

In summary, the study reveals that, although enrollments in agricultural economics programs are continuing to grow, the increase is occurring at a relatively slower rate than at the college level. This increased enrollment, plus the changed background of students coming into agricultural economics programs, will most likely present new challenges for both curricula development and departmental advising programs. While some departments are moving toward some rather specialized program options, the traditional options are still viewed as potential program growth areas.

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An Economic Analysis of a Regionalized Rural Solid Waste Management System: Comment

Wesley N. Musser and Fred C. White

In a recent article, Hardy and Grissom present an analytical procedure for planning rural solid waste disposal systems. The planning model simultaneously considers both location of landfills and the design of collection routes in the efficient organization of a regional solid waste disposal system. Because this problem is beyond the capacity of existing optimal solution algorithms, a stepwise heuristic procedure was developed. The authors can be commended for attempting to develop heuristic methods to analyze complex economic problems of empirical relevance. However, the authors fail to consider if the procedures yield empirical results that are reasonable in comparison with existing economic theory and past empirical analysis. The purpose of this comment is to propose some evaluation standards for Hardy and Grissom's methodology and to compare their empirical results with these standards.

The efficient organization of a solid waste disposal system is a special case of the general economic problem of the efficient location of processing plants that simultaneously considers processing costs and costs of assembly of raw materials from spatially dispersed production areas. The economic relationships involved in this problem are well established in the agricultural economics literature (Bressler and King, Stollsteimer). With economies of scale in processing, a decrease in number of plants decreases processing costs. A compensating increase in assembly costs results from decreasing plant numbers, since the total distance traveled between production and processing sites increases. The optimum number of plants involves a trade-off between these two cost relationships. While these concepts were developed for agricultural processing situations, they can be reinterpreted to encompass the problems of regional provision of rural public services. Holland and Baritelle conceptualize school consolidation problems in a similar framework and find that the same relationships hold. In an earlier study of solid waste disposal, Schreiner, Muncrief, and Davis affirm the applicability of this theoretical framework to solid waste disposal when they state that "combining several communities and service areas for purposes of utilizing common disposal sites and thus reducing unit costs of operation must be compared against increased costs of longer transfer distances in the collection and transfer process" (p. 573).

Considering the theoretical and empirical background in the agricultural economics literature, decreasing processing costs and increasing assembly costs with decreasing number of landfills are surely reasonable expectations for a useful heuristic analytical procedure. While these are only hypotheses, it is a reasonable expectation that research results that are at variance with the rich prior support of these hypotheses should receive explanation. In this comment, these hypotheses are used as standards for evaluation of Hardy and Grissom's heuristic procedure.

Hardy and Grissom's results on disposal costs are largely consistent with the hypothesis of increasing returns to scale in landfill operation. The one exception is in the regional system in which decreasing returns to scale are present as the number of landfills decreases from two to one; disposal costs are $233,535 with two landfills and $236,661 with one. While these cost differences are small, the authors do not even note this exception in the text (p. 183). Since only increasing returns to scale have been evidenced by past research on rural solid waste disposal (Schreiner, Muncrief, and Davis; Carley), decreasing returns to scale with the largest plants are an important empirical result. Furthermore, it is reasonable to expect the authors to explain this unique finding. While decreasing returns to scale for large plants are a part of standard economic theory, the theoretical reason for such a cost relationship—limiting managerial ability—is not a priori applicable to this problem. Would a larger plant in one geographical location be more difficult to manage than two smaller plants in different geographical locations?

Their results on collection costs have more serious variance with expectations from theory and earlier empirical work. In all the single-county systems, collection costs decrease as the number of landfills decreases. In the two-county subregional system, collection costs increase and then decrease as the number of landfills decreases. The three- and four-county systems do follow prior expectations. However, the collection costs for the regional system decrease as landfills decrease from six to two and then increase as landfills decrease from two to one. These results, which for the most part are inconsistent with theory and past research, are noted in the text but not fully explained or synthesized. The au-

Wesley N. Musser is an assistant professor and Fred C. White is an associate professor in the Department of Agricultural Economics, University of Georgia.

thors do attempt to use population density to explain the differences in response of costs to decreasing landfills in the subregional multicounty systems (pp. 182–83). However, they do not explicitly consider the general concept that distance traveled increases as the number of landfills decreases. While the added cost of this increase in distance would be less in a densely populated area, some increase in collection costs would be expected for all systems.

The serious unexplained problems with the results on collection cost indicate that economists could have very little confidence in Hardy and Grissom's heuristic procedures. Inspection of the results in table 2 further reduces the confidence in the methodology. In several cases, combinations of subregional landfills that would serve the entire region have lower total operating costs than the regional landfill systems that Hardy and Grissom describe as least cost. An example of such a combination would be three landfills in the subregional system including Winston, Marian, Franklin, and Colbert counties and two landfills in the Lauderdale County system. This combination would represent a five-landfill regional system and would have operating costs of $310,196 plus $171,800 for a total regional cost of $481,996. This cost is considerably smaller than $552,497, which is the authors' least-cost regional system with five landfills. Other examples of lower cost combinations of subregional landfills than the same number of landfills in the regional solution exist but are not discussed here for the sake of brevity.

In summary, Hardy and Grissom's heuristic procedure does not have much promise. The collection cost relationships are not consistent with expectations based on previous research, and regional results have higher costs than combinations of subregional results in many cases. Even though an optimal procedure is not available, Hardy and Grissom's procedure cannot be expected to be a reliable alternative to independently considering the location of landfills and the design of routes for solid waste collection.

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An Economic Analysis of a Regionalized Rural Solid Waste Management System: Reply

William E. Hardy, Jr., and Curtis L. Grissom

In their comment, White and Musser make some rather strong accusations concerning the reliability of the heuristic procedures used in our article. We agree that inconsistencies exist in the data that could lead to erroneous conclusions. These inconsistencies are not caused by either the location or routing algorithm but by errors and omissions in the budgets that were developed for the analysis.

The questions raised in the comment may be grouped into two general categories: those relating to whether or not the results are consistent with economic theory and those questioning the cost relationships between subregional combinations of landfills that would serve the entire region and the total regional systems. Musser and White are correct in assuming that if regionalization is good then a regional system with a given number of landfills should have a lower cost than a subregional combination.

The data presented in table 1 give revised cost information for specified service areas and numbers of landfill operations. Corrections in the budget

William E. Hardy, Jr., is an assistant professor of agricultural economics, Auburn University, and Curtis L. Grissom is an extension agent, Alabama Cooperative Extension Service.

Table 1. Initial Investment and Annual Operating Costs for Specified Numbers of Landfills

Counties Served	Number of Landfills	Investment	Annual Operating Case		
			Collection	Disposal	Total
Colbert	1	303,780	53,765	70,116	123,881
Colbert	2	384,325	54,448	94,818	149,266
Colbert	3	519,575	92,115	141,090	233,205
Franklin	1	266,750	38,537	55,146	93,683
Franklin	2	328,985	52,898	93,569	146,467
Franklin	3	454,285	73,159	131,965	205,124
Lauderdale	1	446,030	61,562	100,874	162,436
Lauderdale	2	499,145	73,395	126,779	200,174
Lauderdale	3	625,045	79,752	163,395	243,147
Marion	1	240,830	39,664	57,578	97,242
Marion	2	333,375	54,547	94,244	148,791
Marion	3	458,525	73,075	132,680	205,755
Winston	1	211,750	38,225	51,532	89,757
Winston	2	313,815	53,147	86,924	140,071
Winston	3	440,135	72,431	127,841	200,272
Col., Lau [a]	1	613,535	91,003	136,533	227,536
Col., Lau.	2	690,120	112,147	156,583	268,730
Col., Lau.	3	780,370	118,512	195,061	313,573
Win., Mar., Fkl. [b]	1	463,275	110,115	86,897	197,012
Win., Mar., Fkl.	2	543,475	117,223	123,671	240,894
Win., Mar., Fkl.	3	631,675	122,579	162,947	285,526
Win., Mar., Fkl., Col. [c]	1	668,950	146,846	137,203	284,049
Win., Mar., Fkl., Col.	2	732,100	143,840	157,010	300,850
Win., Mar., Fkl., Col.	3	811,700	148,571	193,396	341,967
Region [d]	1	1,120,195	209,439	219,683	429,122
Region	2	1,077,295	200,840	223,410	424,250
Region	3	1,116,295	201,895	242,132	444,027
Region	4	1,197,095	208,679	279,243	487,922
Region	5	1,287,695	217,703	320,154	537,857
Region	6	1,378,895	221,566	356,985	578,551

[a] Colbert and Lauderdale counties.
[b] Winston, Marion, and Franklin counties.
[c] Winston, Marion, Franklin, and Colbert counties.
[d] All five counties.

Table 2. Costs for Solid Waste Management Systems Serving the Five-County Region

System Combination		
Counties	Number of Landfills	Annual Operating Costs
Region [a]	2	424,250
Win., Mar., Fkl. [b]	1	197,012
Col., Lau. [c]	1	227,536
Total		424,548
Region	1	429,122
Region	3	444,027
Lauderdale	1	162,436
Win., Mar., Fkl., Col. [d]	1	284,049
Total		446,485
Lauderdale	1	162,436
Win., Mar., Fkl., Col.	2	300,850
Total		463,286
Col., Lau.	2	268,730
Win., Mar., Fkl.	1	197,012
Total		465,742
Col., Lau	1	227,536
Win., Mar., Fkl.	2	240,894
Total		468,430
Colbert	1	123,881
Lauderdale	1	162,436
Win., Mar., Fkl.	1	197,012
Total		483,329
Winston	1	89,757
Marion	1	97,242
Franklin	1	93,683
Colbert	1	123,881
Lauderdale	1	162,436
Total		566,999

[a] All five counties.
[b] Winston, Marion, and Franklin counties.
[c] Colbert and Lauderdale counties.
[d] Winston, Marion, Franklin, and Colbert counties.

data answer most of the theoretical questions in the comment. A divergence from what would be expected still exists in the collection cost data for the four county combinations (Winston, Marion, Franklin, and Colbert) and in the total regional systems. In each case, the cost of collection is reduced as the second landfill is added but increases thereafter. With each of these operations serving a very large geographic area, the addition of a second collection system permits a substantial decrease in vehicle travel. The savings generated by these reductions exceed the costs of additional management and back-up equipment to support the second system. For any more than two landfills, however, the travel savings are not great enough to overcome the added administrative and support costs.

The data given in table 2 represent the total annual operating costs for various systems that serve the entire five-county region. These cost values indicate (as in Hardy and Grissom, p. 185) that definite savings can be realized through cooperative efforts in providing a solid waste management system for the area under study. The least-cost system is to have two regional sanitary landfills. Numerous other systems, some of which are presented in table 2, give a lower annual operating cost than the system where each county operates independently. This system with an annual operating cost of $566,999 is over 33% more expensive than the least-cost regional system.

We feel that the unreliability contention of Musser and White concerning our simultaneous use of heuristic location and routing algorithms is completely unfounded. The weakness in our procedure is in the development of consistent and accurate budgets for the many county and multicounty combination solid waste management systems that were considered. As better information becomes available from equipment suppliers on the sizes and types of equipment needed for specific sizes of landfill operations, then the budgeting process will become a great deal more precise.

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The Von Thuenen Paradigm, the Industrial-Urban Hypothesis, and the Spatial Structure of Agriculture: Comment

Alan P. Jones, William J. McGuire, and Ann D. Witte

In a recent article in this *Journal,* Katzman offers empirical tests of two models of the intensity of agricultural production in the Goiás region of Brazil.[1] We contend that many of the empirical tests applied to the first of these models, which Katzman describes as a mathematical version of a Von Thuenen type intensity model, are not specified or interpreted appropriately. In particular, given the data at hand, the choice of the dependent variable in many of the regression equations confuses the effects of changes in production technology for a given crop (an intensity model) with the effects of changes in the crops produced (a crop model). Accordingly, many of the results in fact do not refer to an intensity model of agricultural production and therefore cannot be employed to infer an appropriate form for agricultural production functions in Goiás.

Katzman assumes a Cobb-Douglas production function in the theoretical development of his intensity model. Certain a priori expectations about distance-intensity relationships are implied by this functional form, and these are presented in Katzman's table 2. It is clear that these expected distance-intensity relationships are valid only in the production of a single crop. Thus, appropriate empirical tests of these a priori expectations can only be undertaken if crop-specific information is utilized. At several points in the empirical investigations this requirement is not met.

Our reservations are primarily with Katzman's tables 6 and 7. Table 6 reports estimates of factor proportions. In the ten regression specifications presented, it is not clear that any pertain to the single-crop situation. If we assume that the keeping of animal stock is exclusive to cattle raising and that the use of fertilizer is exclusive to rice production, it is possible to interpret equations (3) and (8), and equations (4) and (9), as referring to the single crops meat and rice, respectively. It is not possible, however, to readily identify the dependent variable in any of the other six equations with either activity. Table 6 thus provides at best only insights into capital-land and capital-labor variations with distance in rice and meat production separately. In table 7, equation (5) exhibits like problems with the dependent variable; only equations (1) through (4) may be interpreted as providing adequate representations of output-land and output-labor variations with distance.

Katzman rejects the Cobb-Douglas form of the production function because of certain inconsistencies between his a priori expectations and his empirical results. The stricter interpretation of the regression equations presented above leads us to believe that this rejection is premature. Katzman's inconsistencies 1, 5, and 6 are predicated upon equations (10) and (5) of table 5 and equation (5) of table 7. As noted, we believe all of these equations to be inappropriately specified as they appear to mix information for both meat and rice production. Inconsistency 3, while based upon a correctly specified estimation, clearly refers only to meat production. Inconsistency 4 likewise applies only to rice production. Neither result can be generalized to all agriculture. In addition, the comparison of the price-distance and output per hectare-distance coefficients for 1960, on which inconsistency 4 is based, is open to question. If the true specification is that used for the 1940 estimates, the form of which follows from Katzman's theoretical model, then the equation estimated for 1960 is misspecified because of the exclusion of two explanatory variables. The exclusion of these variables will result in a biased estimate of the coefficient on the distance variable in the 1960 regression (Kmenta, pp. 392–99). The use of this coefficient in drawing inferences is thus suspect, not for data reasons but because of its specification bias.

Finally, we can confirm Katzman's inconsistency 2 for only one of the four rental and price gradient comparisons permitted by the information presented in Katzman's table 4. Due to data limitations, Katzman is only able to estimate both price and rental gradients for a single year, 1970. Thus, appropriate comparisons between these gradients are only possible for this year, and these comparisons are tests of an intensity model only if made on a crop-specific basis. In comparing the price gradient for rice with the rental gradients of arable land and forest land, which Katzman refers to as potential farmland, and the price gradient for

Alan P. Jones and William J. McGuire are graduate students and Ann D. Witte is an assistant professor in the Department of Economics, University of North Carolina, Chapel Hill.

[1] Additional empirical tests are offered in a comment by Garlow. The reservations expressed here extend to certain portions of Garlow's presentation and to Katzman's reply to Garlow.

meat with the rental gradients for natural and planted pasture, we find that only in the last comparison can we accept the hypothesis that the coefficients are not statistically different at the 99% confidence level.[2]

The only conclusions that we feel are warranted by Katzman's empirical results are those based solely upon correctly specified equations, i.e., those that refer to one crop only. These conclusions, which appear to hold for both meat and rice production except where noted, are as follows. (*a*) Land value gradients decline faster than crop price gradients except perhaps for the comparison of meat with planted pasture, where the decline may be equal. (*b*) Capital-land and capital-labor ratios vary inversely with distance. (*c*) Output-land and output-labor ratios vary inversely with distance. None of these results calls for rejection of the hypothesis that each agricultural activity may be characterized by a Cobb-Douglas production function. Nor of course do they offer conclusive support for this hypothesis. The whole question, however, would be better addressed by estimating production functions directly, a point made by Garlow.

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[2] This is based upon the test $\beta_P - \beta_R = 0$, assuming independence between the parameter estimates. This assumption is not as restrictive as it first appears, since if the covariance between the coefficient estimates is positive, the most likely case, then the only effect is upon the power of the test, which would be increased by including the covariance term in the denominator of the test statistic. Thus, the results we report are probably conservative, being possibly biased toward accepting H_o.

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The Von Thuenen Paradigm, the Industrial-Urban Hypothesis, and the Spatial Structure of Agriculture: Reply

Martin T. Katzman

Jones, McGuire, and Witte (J-M-W) present an interesting discussion of the pitfalls of empirically testing the relevance of the Von Thuenen intensity model in the agricultural context. In doing so, they specifically point to some shortcomings of my 1974 and Garlow's papers. In this reply the theoretical criticisms of J-M-W are assayed, and empirical tests are revised along the lines they suggest.

One can easily dispose of the red herring that the neoclassical production relationships presented in my paper do not strictly correspond to Von Thuenen's theoretical presentation. The original paper was less an exercise in intellectual history, reinterpreting what Von Thuenen really said, than a reintroduction of the Von Thuenen paradigm into the analysis of rural spatial structure. A paradigm is simply a broad conceptual scheme that identifies a set of categories, suggests operational measures of these categories, and posits functional relationships that are useful in explanation and prediction and suggestive of further research. Some of the confusion stems from the fact that my paper really deals with two separable but related subjects. The first part shows that a neoclassical version of a Von Thuenen paradigm, which simply postulates that the pattern of urban or rural spatial structure is dominated by the factor of distance from a market center, generates many results similar to the industrial-urban hypothesis, which hitherto was considered a paradigm *sui generis*. The second part of the paper attempts to test whether the Von Thuenen or industrial-urban models could accurately explain the spatial structure of a frontier region in a developing country.

While Von Thuenen obviously predates formal neoclassical analysis and *a fortiori* its mathematical elaborations, there is ample evidence in his examples that as both practicing farmer and scholar he was sensitive to continuous changes in factor proportions (e.g., applications of manure) as a function of distance from the market. He also focused upon discrete changes in production technique, as J-M-W rightly indicate. Which mechanism of intensification applies in a particular situation is an empirical matter. Indeed, our evidence for the period 1940–60 suggests very little land-labor substitution in response to rent gradients. In locations closer to the market, larger amounts of potential farmland were exploited for both intensive (rice) and extensive (cattle) activities and less land was unused. The mechanism of intensification during this period was simply the incorporation of unused land under traditional techniques. Garlow's evidence for 1970, however, persuaded me that by 1970 Goiás agriculture has become more neoclassical (Katzman 1975b). Whether intensification occurs by continuous factor substitution or by discrete changes in technique is less interesting in this context than the fact that distance from the market is the major influence on intensity of land use.

The second objection is that Garlow and myself "combine elements of both the crop and intensity models," and that we do not appear to "clearly recognize the intermingling of the crop and intensity models." This is not quite the case. Goiás was recognized as "the outermost Von Thuenen ring in South-Central Brazil, specializing in the supply of nonperishables, live cattle and rice" (1974, p. 690). This point has been elaborated elsewhere (Katzman 1975a). J-M-W, moreover, seem to misunderstand the crop model, which predicts the existence of rings of monoculture or of distinct crop mixes surrounding a market center. Within any structurally homogeneous ring, several commercial crops may coexist according to the intensity model because of the possibility for sequential cropping, the necessity for rotation when little fertilizer is used, variations in the suitability of land for particular crops, and the need for portfolio diversification. Our implicit assumptions in analyzing Goiás are that until the 1970s rice was essentially the only commercial crop, while cattle was consigned to residual, exhausted land and that within Goiás the percentages of farmland devoted to rice and cattle vary continuously with distance from the market, there being no abrupt shifts to other crop systems.

Since no data are available to permit an allocation of labor or capital between rice and cattle, the original table 6 does not present unambiguous factor proportions. The potential for confusing changing factor proportions and changing mix of rice and cattle then exist as J-M-W intimate. This is not so disastrous, since the amount of both arable land and pasture vary inversely with distance, and the equations in this table can be interpreted as reduced

Martin T. Katzman is a professor and head, Program in Political Economy, University of Texas at Dallas.

Table 1. Man-Farmland Ratios, Goiás, 1940–60

Independent Variable	1940			1950			1960		
	Reduced Form	Recursive Form A	Recursive Form B	Reduced Form	Recursive Form A	Recursive Form B	Reduced Form	Recursive Form A	Recursive Form B
Distance[a]	−0.003	0	—	−0.036	0.008	—	−0.003	0.031	—
	(0.030)[b]	(0.015)		(0.027)	(0.023)		(0.024)	(0.021)	
Fertility	0.725	0.078	—	0.804	−0.155	—	1.003	−0.101	—
	(0.341)	(0.193)		(0.303)	(0.190)		(0.271)	(0.208)	
Percentage of farmland in crops (log)	—	0.802	0.817	—	0.891	0.827	—	0.667	0.603
		(0.096)	(0.085)		(0.079)	(0.079)		(0.100)	(0.067)
Percentage of farmland in pasture (log)	—	0.202	0.190	—	−0.102	−0.091	—	−0.041	0.014
		(0.109)	(0.103)		(0.081)	(0.052)		(0.091)	(0.014)
R^2	0.06	0.75	0.76	0.18	0.77	0.76	0.23	0.71	0.68

Note: Dependent variable in natural logs (n = 52).
[a] Distance in 10 km. units.
[b] Standard errors in parentheses.

forms. These results are intentionally presented in a form compatible with results from tests of the industrial-urban hypothesis, which does not distinguish between crop and intensity effects either.

It was also assumed that almost all labor and nonanimal capital were allocated to the rice crop. This was justified by knowledge of conditions in Goiás and by the finding that is reproduced here (table 1) that the "labor-land ratio . . . is directly related to the share in pasture" (1974, p. 694). These underlying assumptions are made explicit, and the regressions are revised here by allocating all inputs between arable and pasture.

The revised results for capital inputs are similar to the original (table 2). The distance coefficients for the three capital-cropland ratios are generally lower than the original capital-farmland coefficients. The same result holds for animal capital/pasture vis-à-vis animal capital/farmland. This is because the denominators (cropland and pasture) themselves are responsive to distance. In other words, estimated neoclassical factor substitution is weakened when land area is properly measured.

Inconsistency 1 in the original paper—the invariance of the man-farmland ratio with distance from the market—is not eliminated but rather magnified in the revised regression of man-cropland ratios. The resolution of this inconsistency requires an exact allocation of manpower between farming and grazing that cannot be performed with the available data.

In a third set of points, J-M-W discuss the inconsistencies found between the neoclassical model and the empirical results. They quite rightly identify an egregious error in inconsistency 2: the rental

Table 2. Factor Proportions, 1940–60

Dependent Variable (Natural Log)	1940				1950				1960			
	Distance[a]	Fertility	Urbanism	R^2	Distance	Fertility	Urbanism	R^2	Distance	Fertility	Urbanism	R^2
Building $/farmland	−0.015	0.585	0.218	0.49	0.017	0.744	0.098	0.65	−0.013	0.696	0.010	0.44
	(0.003)[b]	(0.337)	(0.164)		(0.004)	(0.298)	(0.038)		(0.003)	(0.373)	(0.007)	
Building $/cropland	−0.015	−0.635	0.072	0.34	−0.009	−0.599	0.087	0.41	−0.004	−0.340	0.015	0.16
	(0.003)	(0.359)	(0.174)		(0.002)	(0.237)	(0.030)		(0.002)	(0.294)	(0.006)	
Machinery $/farmland	−0.009	1.100	0.397	0.28	−0.012	0.747	0.090	0.55	−0.023	0.565	0.017	0.56
	(0.004)	(0.468)	(0.227)		(0.002)	(0.286)	(0.036)		(0.004)	(0.473)	(0.009)	
Machinery $/cropland	−0.004	0.257	0.350	0.04	0.001	−0.025	0.182	0.07	−0.009	−0.222	−0.017	0.23
	(0.004)	(0.493)	(0.239)		(0.004)	(0.548)	(0.069)		(0.003)	(0.406)	(0.008)	
Fertilizer $/farmland	−0.013	0.354	0.407	0.05	−0.241	2.54	−2.15	0.03	−2.87	−271	5.34	0.05
	(0.006)	(0.761)	(0.370)		(0.127)	(15.90)	(2.02)		(1.81)	(230)	(4.51)	
Fertilizer $/cropland	0.008	0.090	0.361	0.10	−0.020	0.459	−0.026	0.22	−0.011	−0.330	0.034	0.27
	(0.003)	(0.407)	(0.200)		(0.006)	(0.703)	(0.089)		(0.004)	(0.565)	(0.011)	
Animal stock $/farmland	−0.008	0.411	0.216	0.26	n.a.	n.a.	n.a.	n.a.	−0.006	0.416	0.005	0.21
	(0.003)	(0.323)	(0.157)						(0.002)	(0.294)	(0.006)	
Animal stock $/pasture	−0.004	0.936	0.158	0.18	n.a.	n.a.	n.a.	n.a.	−0.003	0.567	0.001	0.06
	(0.003)	(0.356)	(0.173)						(0.003)	(0.319)	(0.006)	
Man/farmland	0	1.12	0.072	0.12	−0.004	0.804	0.052	0.21	−0.002	0.732	0.001	0.07
	(0.003)	(0.38)	(1.180)		(0.003)	(0.303)	(0.300)		(0.003)	(0.343)	(0.007)	
Man/cropland	0.001	−0.092	−0.074	0.05	0.005	−0.185	0.041	0.21	0.008	−0.304	0.006	0.27
	(0.002)	(0.222)	(0.108)		(0.002)	(0.198)	(0.023)		(0.002)	(0.247)	(0.005)	

[a] Distance in 10 km. units.
[b] Standard error in parentheses (48 d.f.).

gradient does not have the same slope as the price gradient as stated originally; the land value gradient declines considerably faster than the crop price gradients in 1950–70. From a neoclassical production function with a land coefficient of 0.7, one expects the rental gradient (gk/a from equation (16)) to be about 1.5 times greater than the price gradient ($-gk$). In fact, the land value gradient is three to five times greater than the price gradient, which is explicable only by a substantial interest rate gradient (1974, p. 692, fn. 8). An inconsistency thus remains to be explained.

Inconsistencies 3 and 4—the gradients of animal capital/farmland and crop output/farmland were equivalent to the respective price gradients in 1960—are not as troublesome as J-M-W make them to be. In the corrected regressions, animal capital/pasture is significantly less steep than the beef price gradient, an inconsistency that cannot be easily explained.

Inconsistency 5—the value of land inputs per man varies inversely with distance—is not problematic either. In the original table 4, one finds that the gradient for improved farmland and improved pasture are similar and that the gradient for unimproved farmland (forest) and natural pasture are similar. The changing mix of land use between rice and cattle should not affect the observed ratio of land value per man.

Contrary to the third conclusion of J-M-W, the inverse relationship between output per man and distance from the market is inconsistent with a Cobb-Douglas function in which wages are invariant or decreasing with distance. Second, given their objections to our measures of output/farmland, there is no way to determine whether the gradient of rice output/cropland or cattle output/pasture is steeper than the corresponding price gradients.

While there is no disputing the second conclusion of J-M-W that capital-land and capital-labor ratios vary inversely with distance, this does not temper my earlier conclusion of limited land-labor factor substitutability.

It is clear from my original paper, the comments of Garlow and J-M-W, and this reply that the available data from Goiás are as underdeveloped as its agriculture and that refined discriminations between neoclassical and fixed-proportions production models cannot be drawn. This is really a side issue, since the point of the original article was not to estimate production functions. The two original arguments stand: that many of the deductions of the industrial-urban hypothesis can be arrived at through a neoclassical Von Thuenen model and that the spatial structure of the Goiás rice and cattle economy is largely determined by distance from the market and modified by access to local centers of industrial urbanism.

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Optimum Resource Allocation in U.S. Agriculture: Comment

C. Richard Shumway, Bruce R. Beattie, and Hovav Talpaz

Over ten years ago, Tyner and Tweeten presented two imaginative and pervasive articles in this *Journal*. The first notes past statistical difficulties in obtaining reliable parameter estimates for aggregate U.S. farm production functions with several input variables (Tyner and Tweeten 1965). In proposing an alternative approach, Tyner and Tweeten note that factor elasticities must equal their respective factor shares, given the assumptions of perfectly competitive product and factor markets and market equilibrium.[1] They also assume that entrepreneurs attempt to organize production such that actual factor shares adjust toward an equilibrium in a geometric distributed lag fashion. Since the parameters of a Cobb-Douglas production function are factor elasticities, they propose computing elasticities from historical data on factor shares, avoiding the problem of multicollinearity. Estimates of factor elasticities for nine input categories were developed by decade for 1912–61 using data from published and unpublished ERS sources.

The second article (1966) built upon the first by incorporating these elasticity estimates into a Cobb-Douglas production function for each decade. This was accomplished by regressing farm output (in constant dollars) on a composite input variable (in constant dollars) defined as the product of each factor raised to its exogenously estimated factor elasticity. A linear model with a zero intercept was used to estimate the constant term for each decade. Having in this manner synthesized a production function, minimum-cost input levels, equilibrium output and input levels, factor-substitution relationships, and factor-demand and product-supply elasticities were derived, and comparisons were made with the actual situation in each decade. Based on these comparisons, Tyner and Tweeten conclude (*a*) adjustment to a least-cost input combination to produce the actual average 1952–61 output would have reduced the input dollar volume by $1.9 billion, or 5.6%; (*b*) adjustment of farm resources to an equilibrium level with all variable resources earning an opportunity-cost return would have entailed a reduction of $4.2 billion ($1947–49), or 12.5% of the actual input volume in the 1952–61 period; (*c*) labor was in excess supply by two-fifths in the 1952–61 period;[2] and (*d*) capital inputs supplied by the nonfarm sector were not generally used in excess by farmers (1966, pp. 629–30). In summary, their results "serve as a guideline for public policy by indicating the magnitude of resource adjustment needed to achieve economic equilibrium, and the economic cost of maintaining nonoptimal resource levels and combinations in agriculture" (1966, p. 630).

These were, and remain, important conclusions resulting from an ambitious and innovative study—conclusions that added empirical credence to the popular notion of substantially excess labor resources in agriculture. The conceptual, methodological, and policy significance of this work was emphasized by the inclusion of the second article in the *A.E.A. Readings in Agricultural Economics*. Impressed with the ingenuity of the Tyner and Tweeten approach and its implications for agricultural policy analysis, we, like others, have used their articles in graduate teaching. In so doing, we have discovered an error in the Tyner and Tweeten analysis that substantially affects the policy conclusions presented in the second article. It is the purpose of this comment to present revised results for an article that remains an important source of economic hypotheses and policy prescriptions even a decade later.

Alternate Model Specifications

The error in Tyner and Tweeten's analysis—an error the consequence of which led to a substantial overstatement of resource misallocation in U.S. agriculture—is addressed by considering the first-order conditions for profit maximization under two alternative specifications of the production function

C. Richard Shumway, Bruce R. Beattie, and Hovav Talpaz are associate professors of agricultural economics, Texas A&M University.

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[1] Each factor elasticity, $E_i = MPP_i/APP_i$, equals its share of total value product expressed as the ratio of expenditure on the input ($r_i x_i$) to total value product (py). Given perfect competition and equilibrium, $MPP_i = r_i/p$, implying that $MPP_i x_i/y = r_i x_i/py$ or $E_i = r_i x_i/py$, where MPP_i, APP_i, and r_i are the marginal productivity, average productivity, and price of the ith factor, respectively; y denotes product and p the product price.

[2] There is a discrepancy in Tyner and Tweeten (1966) as to the extent of excess labor supply in the 1952–61 decade. In the text a two-fifths excess supply is mentioned, but in table 5 a 68% excess is implied.

(i.e., in physical versus constant dollar units) and two objective functions (i.e., in nominal versus constant dollar prices). (We are indebted to the *Journal* editors for suggesting this expositional approach.)

Starting with the conventional case in which output (y_t) and inputs (x_{it}) in time period t are measured in physical units, the production function is given by

$$(1) \qquad y_t = f_t(x_{1t}, \ldots, x_{nt}).$$

With p_t and r_{it} being product and factor i price, respectively, and assuming zero price flexibilities, profit π_t in any time period t is expressed in actual prices prevailing in that period:

$$(2) \qquad \pi_t = p_t f_t(x_{1t}, \ldots, x_{nt}) - \sum_i r_{it}x_{it},$$

and first-order conditions for maximizing nominal profits are

$$(3) \qquad \partial\pi_t/\partial x_{it} = 0 \Rightarrow \partial y_t/\partial x_{it} = r_{it}/p_t.$$

An equivalent approach is needed when output and inputs are measured as revenue and expenditures in base period ($t = b$) prices as was Tyner and Tweeten's case for all inputs except labor (which was measured in man-hours). This production function is given by

$$(4) \qquad p_b y_t = f_t(r_{1b}x_{1t}, \ldots, r_{nb}x_{nt}).$$

Profit in any year t is

$$(5) \qquad \pi_t = (p_t/p_b)f_t(r_{1b}x_{1t}, \ldots, r_{nb}x_{nt}) - \sum_i (r_{it}/r_{ib})r_{ib}x_{it},$$

where the appropriate product and factor prices are actual prices deflated by base period prices, i.e., p_t/p_b and r_{it}/r_{ib}, respectively. These are the nominal price equivalents of a product or factor measured in constant dollars. First-order conditions for maximizing profits are

$$(6) \qquad \partial\pi_t/\partial r_{ib}x_{it} = 0 \Rightarrow \partial p_b y_t/\partial r_{ib}x_{it} = r_{it}p_b/r_{ib}p_t.$$

With the base year prices (p_b and r_{ib}) specified as unity, equation (6) is equivalent to equation (3). The only difference between equations (3) and (6) is that the former is measured in physical output and input units and nominal prices per physical unit and the latter is in constant dollar output and input units and nominal prices per constant dollar unit. For any time period t, producers, if rational and all the usual assumptions of static analysis are satisfied, allocate resources according to the conditions specified in equation (3) or (6). Either of these approaches is appropriate and yields equivalent results as resource allocation decisions are (and should be) based on existing (or anticipated) prices in that period.

Rather than following the approach in equations (5) and (6), Tyner and Tweeten implicitly assume a different specification of the objective function. They express product and input prices as well as input and output levels in constant (base period) prices; that is, given the production function expressed in constant dollars (equation (4)), the following is maximized:

$$(7) \qquad \pi_t = (p_b/p_b)f_t(r_{1b}x_{1t}, \ldots, r_{nb}x_{nt}) - \sum_i (r_{ib}/r_{ib})r_{ib}x_{it}.$$

First-order conditions would then be

$$(8) \qquad \partial\pi_t/\partial r_{ib}x_{it} = 0 \Rightarrow \partial p_b y_t/\partial r_{ib}x_{it} = r_{ib}p_b/r_{ib}p_b = 1.$$

Maximizing profit so expressed results in the same first-order conditions for every period and fails to take account of the prices actually faced by producers in any time period except the base period. Yet it is this function that Tyner and Tweeten apparently sought to maximize.

Except for labor, their input and output data series are measured in 1947–49 constant dollars. Consequently, the appropriate first-order conditions are those of equation (6). Yet, it appears that they use base period prices to derive least-cost input combinations, etc., in every decade despite the fact that those prices are relevant only in the 1947–49 base period. Tyner and Tweeten acknowledge assuming prices of \$1 for output and all inputs except labor (1966, p. 617). Further, their results can be duplicated when prices of \$1 are used in all decades but not when nominal prices are used.

The use of constant prices rather than nominal prices has a major empirical consequence as is demonstrated in this note by comparing results using prices actually prevailing in each decade with the results of the \$1 prices used by Tyner and Tweeten. Nominal price equivalents (hereafter referred to simply as "nominal prices") (i.e., p_t/p_b and r_{it}/r_{ib}) can be computed directly from their two data series—a USDA nine-input data series of $p_b y_t$ and $r_{ib}x_{it}$, measured in 1947–49 constant dollars, and a comparable series developed by Tyner and Tweeten in current dollars, i.e., $p_t y_t$ and $r_{it}x_{it}$. Prices (p_t/p_b and r_{it}/r_{ib}) are given by dividing the respective current dollar series by the constant dollar series. These prices are reported in table 1 as decade averages and are substantially different from the 1:1 ratios assumed by Tyner and Tweeten.

Implications

We compare several results—minimum-cost input combinations, supply function, and equilibrium output and input levels—by using Tyner and Tweeten's aggregate U.S. production functions and correcting the output and input prices used.[3] Our

[3] The parameters of the aggregate U.S. agricultural production function estimated by Tyner and Tweeten for each decade, 1912–61, are accepted for purposes of this exposition without challenge. Our efforts to reestimate those parameters using an alternative distributed lag hypothesis result in only minor differences (Shumway, Talpaz, and Beattie).

Table 1. Nominal Output and Input Prices by Decade

Output or Input	1912–21	1922–31	1932–41	1942–51	1952–61
Output	0.602	0.572	0.422	0.945	0.967
Inputs					
Fertilizer and lime	1.329	1.100	0.808	0.979	0.970
Feed, seed, and livestock	0.528	0.491	0.399	0.870	0.928
Labor	—[a]	—[a]	0.145	0.501	0.758
Machinery	0.577	0.641	0.627	0.962	1.422
Real estate	1.033	1.088	0.667	1.124	1.864
Machinery operating expenses	1.122	0.905	0.732	0.948	1.203
Misc. operating expenses	0.639	0.722	0.596	0.998	1.128
Crop and livestock inventory	0.540	0.500	0.359	0.867	0.906
Real estate taxes	0.571	0.626	0.491	0.884	1.155

[a] Labor data incomplete.

Table 2. Estimated Minimum-Cost Levels of Inputs Required for Average Actual Output by Decades, 1912–61

Input	Item[a]	1912–21	1922–31	1932–41	1942–51	1952–61
		Million 1947–49 Dollars[b]				
Fertilizer and lime	T-T	261.9	333.0	626.0	975.0	1,282.0
	T-T*	161.4	261.1	289.2	719.9	1,364.2
	A	182.7	249.2	286.4	753.4	1,364.7
Feed, seed, and livestock	T-T	381.2	425.6	1,457.8	2,962.0	2,627.3
	T-T*	591.5	747.5	1,363.5	2,460.7	2,922.4
	A	528.7	761.1	896.7	1,978.4	2,698.0
Labor	T-T	—[c]	—[c]	9,388.6	10,566.0	6,280.6
	T-T*	—[c]	—[c]	21,096.9	16,809.3	11,688.6
	A	23,400.3	23,277.2	21,075.0	17,855.1	11,782.2
Machinery	T-T	1,065.6	809.5	1,431.9	2,642.8	2,789.3
	T-T*	1,513.0	1,088.6	851.4	1,972.7	2,023.6
	A	1,000.1	1,187.8	1,066.2	1,606.8	2,642.4
Real estate	T-T	4,033.6	4,191.8	5,584.7	5,014.2	7,060.0
	T-T*	3,198.1	3,322.8	3,122.5	3,224.8	3,907.9
	A	3,387.2	3,389.9	3,356.6	3,471.5	3,742.8
Machinery operating expenses	T-T	315.9	655.2	1,539.9	2,331.8	3,059.9
	T-T*	230.6	624.5	784.4	1,779.0	2,624.1
	A	331.2	558.4	743.9	1,783.7	2,502.4
Misc. operating expenses	T-T	971.4	1,122.1	1,785.2	1,734.6	2,310.5
	T-T*	1,244.2	1,356.4	1,116.6	1,256.5	2,113.1
	A	1,342.2	1,337.3	1,121.9	1,411.0[d]	2,100.7
Crop and livestock inventory	T-T	656.3	632.8	1,084.7	1,500.7	1,219.0
	T-T*	995.9	1,092.0	1,127.0	1,251.1	1,388.5
	A	1,106.5	1,079.2	1,102.7	1,314.7	1,441.4
Real estate taxes	T-T	374.7	649.7	912.8	697.4	1,050.0
	T-T*	537.2	895.6	694.0	583.9	938.0
	A	546.7	853.5	825.1	643.1	902.2
Average output		17,822.7	19,791.4	20,737.5	27,291.7	32,452.5

[a] T-T is the minimum-cost level reported by Tyner and Tweeten (1966, table 2) with labor priced at 85% of the nonfarm rate and all other inputs at $1; T-T* is the minimum-cost level using appropriate nominal input prices; A is the actual average for the period as reported by Tyner and Tweeten (1966, table 2).

[b] Except for labor, which is in million man-hours.

[c] Insufficient data to compute.

[d] Tyner and Tweeten report this figure as 1,211.0. Other differences between their reported averages and the decade averages of the Tyner data (appendix A, tables 2 and 3) are minor.

results are contrasted with those of Tyner and Tweeten, where their derivations assumed labor priced at 85% of the nonfarm rate.

Minimum-Cost Input Combinations

Minimum-cost input levels and actual expenditure levels (A) in constant dollars are presented by decade in table 2. Results using nominal prices (T-T*), as compared with the original Tyner and Tweeten results (T-T), were closer to actual expenditures in thirty-six of the forty-three cases.

Minimum-cost labor and land inputs were much closer to actual than implied by Tyner and Tweeten. Labor was in equilibrium in the 1932–41 decade and was in excess supply by only 6.2% in 1942–51 and 0.8% in 1952–61. Actual real estate level was also closer to the minimum-cost level: 5.9% in 1912–21, 2.0% in 1922–31, 7.5% in 1932–41, 7.7% in 1942–51, and −4.2% in 1952–61. In no period was labor in substantially excess supply nor real estate greatly below the minimum-cost level. These findings are in direct contrast to Tyner and Tweeten's conclusion that labor was greatly in excess supply and real estate in short supply in all decades.

With all inputs priced at $1 per unit, except labor, which they priced at 85% of the nonfarm rate, Tyner and Tweeten's estimates imply that input costs could have been lowered by 18.7% in the 1932–41 decade, 9.1% in the 1942–51 decade, and 10.5% in the final decade. However, with inputs correctly priced, the opportunity for reducing production costs is substantially less. Input costs could have been lowered by only 1.5% in the 1932–41 and 1942–51 decades and 0.9% in the 1952–61 decade. The large misallocation of resources suggested appears to have been illusory.

Because real estate enters their original derivations at levels higher than they believed reasonable (1966, p. 618), Tyner and Tweeten recalculated the minimum-cost combination of other inputs holding real estate fixed at actual average decade levels. Holding real estate fixed changed the minimum-cost combination of other inputs in their original calculations substantially and increased total cost of inputs by 3.9% in the 1932–41 decade, 1.3% in the next, and 5.4% in the final decade. Using nominal prices, the relative impact on input combinations and total cost was considerably less. The differences between assuming all factors variable and real estate fixed are minor when the appropriate nominal prices are used.

Equilibrium Output and Input Combinations

The aggregate U.S. agricultural supply and demand situation for the 1952–61 decade is depicted in figure 1. Demand curve D_{T-T} is that reported by Tyner and Tweeten (1966, p. 623). Demand curve D_{T-T^*} is the T-T demand curve using the nominal 1952–61 product price—0.967 (i.e., $\bar{P}^*$). In deriving their demand curve (D_{T-T}), Tyner and Tweeten assume an elasticity of −0.25 and pass a straight line through the output point ($\bar{Y}$) at the assumed output price ($\bar{P}$, i.e., 0.904), in figure 1. This output, $30,933 million ($1947–49), represents their estimate of farm output in the absence of government programs (5% lower than actual farm output—$\bar{Y}$). Our demand curve (D_{T-T^*}) was developed similarly using the nominal output price ($\bar{P}^*$).

The product supply functions presented in figure 1 assume perfectly elastic input supply functions except for real estate, which was presumed fixed. The supply function derived by Tyner and Tweeten assuming labor priced at 85% of the nonfarm wage rate is identified as S_{T-T}. With nominal output and input prices, the supply function is represented by S_{T-T^*}.

Each of these supply functions is supposedly derived based on expansion path conditions. Yet the T-T supply function lies above their estimated point of actual decade production adjusted for the effect of government programs ($\bar{Y}\bar{P}$). Thus, the implication is that producers were actually more efficient than they would have been if they had combined inputs optimally. The real reason that S_{T-T} lies above the point of actual production is that incorrect prices were assumed. Among other differences, the labor price was too high and output and real estate prices were too low. The supply function based on nominal prices (S_{T-T^*}) lies below our estimated point of actual adjusted production ($\bar{Y}$, $\bar{P}^*$) as indeed it must if any misallocation of resources is to be claimed.

As expected, equilibrium output level based on nominal prices ($\bar{Y}_{T-T^*}$) was greater than the adjusted actual output ($\bar{Y}$), but only slightly. Output was 0.6% above adjusted actual as opposed to Tyner and Tweeten's estimate of 2.1% lower. Elasticity of product supply was unaffected by using nominal prices; with real estate fixed, it was 3.41 for both S_{T-T} and S_{T-T^*}.

At the estimated equilibrium output level, Tyner and Tweeten conclude that labor was greatly in excess supply in the 1952–61 decade. Our findings using nominal prices indicate that it was much closer to optimal—only 5.0% in excess. They determine that there was underinvestment in capital items purchased from the nonfarm sector (i.e., all inputs except labor and real estate); our findings indicate overinvestment of about 6%. Their results indicate that machinery was used at less than the optimal level, yet we observed usage more than one-third greater than optimal.

Tyner and Tweeten conclude that adjustment of farm resources to an equilibrium level would have reduced actual input volume by 12.5%. We estimate that adjustment to equilibrium would have reduced expenditures only 4.9%. They further estimate that slightly more than half of this reduced volume of inputs would occur through reducing output level

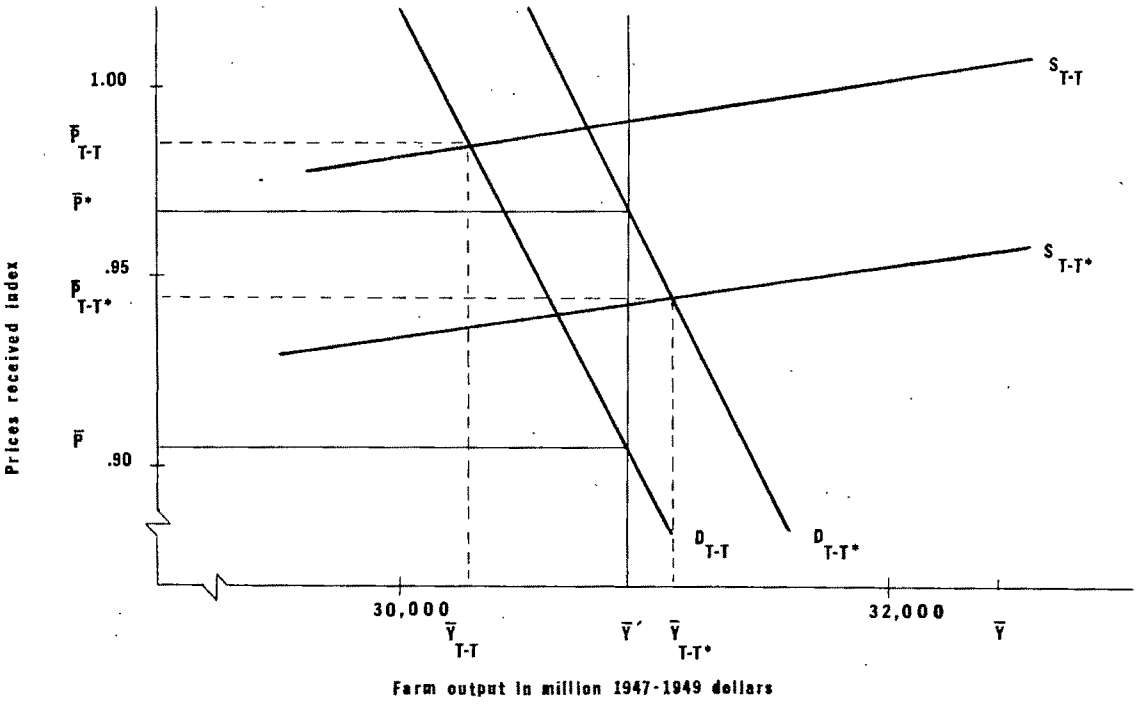


Figure 1. Aggregate farm demand and supply for the 1952–61 period

and the remaining half through using the least-cost input combination. We estimate that less than one-sixth of the reduction could occur through reorganizing the input mix, and the remainder would be due to lowering output from its actual unadjusted level ($\bar{Y}$ in figure 1).

Conclusions

The pioneering research by Tyner and Tweeten, reported in two articles in this *Journal* in the mid-1960s, was and remains imaginative and comprehensive. However, an important error exists in their analysis, viz., inappropriate product and factor prices were used in estimating the extent of nonoptimality in input usage in U.S. agriculture. Consequently, Tyner and Tweeten's conclusions (1966) regarding differences between optimal and actual input usage appear not to be reliable as policy prescriptions. Many of the implications for "desired" change in factor usage were reversed in this study. Of major importance is the apparent large overestimation of excess labor in agriculture.

The following conclusions based on nominal prices are presented in contrast to the four Tyner and Tweeten conclusions presented at the beginning of this paper: (*a*) adjustment to a least-cost input combination to produce the actual average 1952–61 output would have reduced the input dollar volume by $282 million or 0.9% (i.e., less than one-fifth as much reduction as the Tyner and Tweeten estimate); (*b*) adjustment of farm resources to an equilibrium level in the 1952–61 decade, with all variable resources earning an opportunity-cost return, would have entailed a reduction of $1.5 billion or 4.9% of the input volume (i.e., less than two-fifths as much savings as the Tyner and Tweeten estimate); (*c*) labor was in excess supply by only 5% in the 1952–61 period (i.e., only about one-tenth the Tyner and Tweeten estimated oversupply); and (*d*) capital inputs supplied by the nonfarm sector were used in slight excess (6.3%) by farmers in this period, and machinery in particular was used in substantial excess (36%).

While both farm output and input combinations appear to be somewhat out of equilibrium, that disequilibrium in the 1952–61 decade was apparently no more than about two-fifths the magnitude estimated by Tyner and Tweeten (1966). Thus, farmers appear to be producing considerably more efficiently than previously intimated. Further, as an anonymous reviewer pointed out, if adjustment costs were fully endogenized into the adjustment model, it seems reasonable to hypothesize that differences between optimal and actual resource allocation would be negligible.

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Optimum Resource Allocation in U.S. Agriculture: Reply

Fred Tyner and Luther Tweeten

Shumway, Beattie, and Talpaz contend that "Tyner and Tweeten's conclusions (1966) regarding differences between optimal and actual input usage appear not to be reliable as policy prescriptions." The authors of the comment have also distributed a publication on the same topic that has the purpose to "critically evaluate the validity of the key assumption that factor shares adjust toward equilibrium in a geometric distributed lag fashion and to determine whether there are significant differences in equilibrium factor shares between decades" (Shumway, Talpaz, and Beattie, p. 3). The publication states three conclusions:

> 1. Tyner and Tweeten's choice of a geometric distributed lag specification for the adjustment model seems adequate for the data and time periods upon which their study was based. 2. Differences in estimated factor elasticities between decades are for the most part nonsignificant. 3. Tyner and Tweeten's conclusions regarding substantial misallocation of resources in U.S. agriculture are unfounded because they were based on an inappropriate set of product and factor prices. Importantly, labor was not nearly so much in excess supply . . . as originally suggested . . . (Shumway, Talpaz, and Beattie, summary).

The main difference between the conclusion in their comment (and the third conclusion in their 1977 publication) and ours results from a simple but highly significant error in their procedure. We examine first the combinations of inputs that would have provided the average output levels during the 1932–61 period at the least cost.[1]

Minimum-Cost Input Levels

The basic point in the argument of Shumway, Beattie, and Talpaz is that an error exists in the input and output prices used. We did state, since input and output levels were expressed in value terms based on 1947–49, that "the prices of these inputs are assumed to be $1" (p. 617, fn. 4). In their comment, they note correctly that the price of the ith input should have been r_{it}/r_{ib}, where t is current dollars and b represents base periods prices. (They acknowledge the *Journal* editors for suggesting this expositional approach.) Shumway, Beattie, and Talpaz state that "Nominal price equivalents . . . can be computed directly from their two data series . . . by dividing the respective current dollar series by the constant dollar series."

This they did, using appendix data from Tyner, presenting the results in their table 1. By these conclusions they recovered, with one vital exception, the respective U.S. Department of Agriculture series on "prices paid for items used in production, 1947–49 = 100." The exception is the labor input nominal price, which they incorrectly calculate as the ratio of a current dollar series to a man-hour series (not a base period value series). The nominal labor prices by decade that they obtain are 0.145 for 1932–41, 0.501 for 1942–51, and 0.758 for 1952–61, whereas the appropriate values are 0.748, 1.042, and 1.230 for the three decades, respectively.[2]

We examine Shumway, Beattie, and Talpaz's assertions by recalculating the least-cost combinations using their "nominal prices." These results, labeled SBT* in our table 1, differ from theirs by negligible amounts attributable to truncation and rounding errors in logarithms.[3] The next step in our analysis is to use all of their input prices except labor (we used the 0.748, 1.042, and 1.230 values) to calculate the minimum-cost input levels. These results, labeled T-T (1977) in table 1, are not substantially different from our results published in this *Journal* in 1966. Actual labor usage exceeded the least-cost levels by 153% in 1932–41, by 66% in 1942–51, and by over 42% in 1952–61. Actual real estate inputs were judged to be below optimum in our original results, and the revised results T-T (1977) agree, indicating that real estate inputs should have been higher by 54%, 24%, and 20% in the three decades, respectively.

The average values (in million 1947–49 dollars) of inputs used during the three decades (pricing labor at 85% of the nonfarm wage rate) were $25,163, $31,599, and $31,887, respectively. In contrast, the calculated least-cost levels shown as T-T (1977)

Fred Tyner is a professor of agricultural economics, Mississippi State University, and Luther Tweeten is Regents professor of agricultural economics, Oklahoma State University.

Journal articles 3229 of the Oklahoma Agricultural Experiment Station and 3596 of the Mississippi Agricultural and Forest Experiment Station.

[1] The 1912–31 period is omitted for brevity and because the original results did not include a "least-cost" quantity of labor. The importance of the labor variable in this exchange will become clear shortly.

[2] The appropriate "prices" are 85% of the average values for the index "price of nonfarm labor, 1947–49 = 100."

[3] Our comparative results, including converting arithmetic data to logarithms, were obtained using the UNIVAC 1108 system, Thomas E. Tramel Computing Center, Mississippi State University.

Table 1. Estimated Minimum-Cost Levels of Inputs Required for Average Actual Output by Decades, 1932–61

Input[a]	Item[b]	1932–41	1942–51	1952–61
Fertilizer and lime	T-T (1966)	626.0	975.0	1,282.0
	A	286.4	753.4	1,364.7
	SBT	289.2	719.9	1,364.2
	SBT*	291.3	720.0	1,364.1
	T-T (1977)	498.6	961.3	1,567.1
Feed, seed, and livestock	T-T (1966)	1,457.8	2,962.0	2,627.3
	A	896.7	1,978.4	2,698.0
	SBT	1,363.5	2,460.7	2,922.4
	SBT*	1,373.6	2,461.8	2,921.6
	T-T (1977)	2,350.6	3,286.9	3,356.2
Labor	T-T (1966)	9,388.6	10,566.0	6,280.6
	A	21,075.0	17,885.1	11,782.2
	SBT	21,096.9	16,809.3	11,688.6
	SBT*	21,317.1	16,804.9	11,698.1
	T-T (1977)	8,321.2	10,787.6	8,281.5
Machinery	T-T (1966)	1,431.9	2,624.8	2,789.3
	A	1,066.2	1,606.8	2,642.4
	SBT	851.4	1,972.7	2,023.6
	SBT*	858.6	1,972.9	2,024.1
	T-T (1977)	1,469.4	2,634.1	2,325.3
Real estate	T-T (1966)	5,584.7	5,014.2	7,060.0
	A	3,356.6	3,471.5	3,742.8
	SBT	3,122.5	3,224.8	3,907.9
	SBT*	3,036.3	3,225.2	3,909.0
	T-T (1977)	5,183.6	4,306.1	4,490.5
Machinery operating expenses	T-T (1966)	1,539.9	2,331.8	3,059.9
	A	743.9	1,783.7	2,502.4
	SBT	784.4	1,779.0	2,624.1
	SBT*	791.0	1,778.6	2,624.8
	T-T (1977)	1,353.6	2,374.7	3,015.3
Miscellaneous current operating expenses	T-T (1966)	1,785.2	1,734.6	2,310.5
	A	1,121.0	1,411.0[c]	2,100.7
	SBT	1,116.6	1,256.5	2,113.1
	SBT*	1,126.1	1,256.6	2,113.7
	T-T (1977)	1,927.1	1,677.8	2,428.1
Crop and livestock inventory (interest)	T-T (1966)	1,084.7	1,500.7	1,219.0
	A	1,102.7	1,314.7	1,441.4
	SBT	1,127.0	1,251.1	1,388.5
	SBT*	1,135.8	1,251.5	1,388.6
	T-T (1977)	1,943.8	1,671.0	1,595.1
Real estate taxes	T-T (1966)	912.8	697.4	1,050.0
	A	825.1	643.1	902.2
	SBT	694.0	583.9	938.0
	SBT*	699.0	583.7	938.2
	T-T (1977)	1,196.3	779.4	1,077.8
Average output		20,737.5	27,291.7	32,452.5

[a] Results by Tyner and Tweeten are based on labor priced at 85% of the nonfarm wage rate.
[b] Results are T-T (1966) = original results; A = actual average inputs; SBT = Shumway, Beattie, and Talpaz; SBT* = results obtained by Tyner and Tweeten using SBT prices; T-T (1977) = results using SBT prices except for labor.
[c] This value, miscellaneous current operating expense in 1942–51, was incorrectly reported as 1,211 in the original article.

amounted to only $22,147, $28,932, and $30,042, respectively, indicating the opportunity for reducing production costs by 12.0%, 8.4%, and 5.8%. Thus, the statement by Shumway, Beattie, and Talpaz that the "large misallocation of resources suggested appears to have been illusory" is incorrect.[4] Our results are buttressed by other studies using very different methodologies but showing an

[4] The original estimates T-T (1966) suggest possible cost savings of 14.8%, 8.7%, and 8.7% for the three decades, respectively.

even larger economic disequilibrium. A review of literature concerning this issue provides conclusions from more disaggregated analyses that are consistent with ours (Kaldor and Saupe, Tweeten and Walker).

Equilibrium Output and Resource Levels

Shumway, Beattie, and Talpaz present "nominal output prices" of 0.422, 0.945, and 0.967, respectively, for the three decades 1932–41, 1942–51, and 1952–61 in their table 1. We were unable to find data to reproduce these figures. However, the theoretical basis for their prices was stated as p_t/p_b (i.e., the current year price divided by the base year price). The analogous index—prices received by farmers, 1947–49 = 100—has average values of 0.364, 0.873, and 0.904 for the three decades (USDA).

A disequilibrium in the input mix means that any given output could have been produced at a lower cost, increasing the profitability of that given level of output. Further, the fact that demand for farm products is inelastic means that total revenue could be increased by lowering output. These conclusions strongly suggest that profit increases may well involve a reduction in output and a concomitant adjustment in resource use. Shumway, Beattie, and Talpaz on the other hand attempt to justify their equilibrium output result for 1952–61 by stating "As expected, equilibrium output . . . was greater than the adjusted actual output . . ." and by talking about an undefined "efficiency."

Their assertions regarding the incorrectness of our equilibrium output estimates stem from their use of an incorrect price for labor (as discussed in the previous section). Had they used the correct labor price, they would also have found a disequilibrium in resource use. Our results, showing an optimum output level smaller than the actual 1952–61 output, are compatible with our 1966 results, with the T-T (1977) results of this reply, and with economic logic.

Other Remarks

Shumway, Beattie, and Talpaz state that our original estimates imply that input costs could have been lowered by 18.7%, 9.1%, and 10.5%. The origin of these figures is unclear; our correctly calculated figures are 14.8%, 8.7%, and 8.7%.

They also state in footnote 2 of their comment that a discrepancy exists as to the extent of the excess labor supply in the 1952–61 decade. In 1966, we stated (p. 629) that labor was in excess by two-fifths in 1952–61. Alternatively, in table 5, actual labor was reported to be 168% of equilibrium labor. A minor mathematical calculation indicates that the excess is, in fact, two-fifths of the total labor; that is, $(11{,}782.2 - 7{,}009.7) \div 11{,}782.2 = 0.4051$.

The authors of the comment conclude that the equilibrium output in 1952–61 should have been greater than the actual output, a highly questionable result when one considers that this period was one of recognized surpluses in agricultural output.

The intent of the original article in 1966 was to measure disequilibrium in resource allocation in U.S. agriculture. The conclusions developed at that time were consistent both with economic theory and with observation of actual circumstances within agriculture. As the result of reexamining our analysis, we find those conclusions to be unchanged and the policy implications valid.

[*Received May 1977.*]

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Optimum Resource Allocation in U.S. Agriculture: Rejoinder

C. Richard Shumway, Bruce R. Beattie, and Hovav Talpaz

Tyner and Tweeten's (1966) estimates of equilibrium factor shares were indirect estimates of the exponent parameters for Cobb-Douglas production functions. Given these production functions, they addressed the issue of resource missallocation in each of five decades. Subsequently, we solved for optimum input combinations using the decade averages of the same prices (including the labor wage rate) as those implicit in Tyner and Tweeten's factor share data and concluded there was no evidence that the use of any input was greatly out of equilibrium. This result was quite different than that offered by Tyner and Tweeten in their original article and in their reply to our comment.

While they acknowledge in general (for eight of nine input categories) that inappropriate prices were used in their original work, Tyner and Tweeten do not acknowledge any error with regard to the labor price used. The upshot of their reply is that only minor differences in results occur when just the nonlabor prices are corrected, and the implications of their original article for resource misallocation in agriculture still hold. They further suggest that we erred in the labor price used in the analysis reported in our comment. We think not.

Tyner and Tweeten used the *hired farm labor* wage rate to determine current expenditures on all farm labor, which in turn were used in the factor share adjustment model to estimate labor's production elasticity. They then suggest in their reply that "the appropriate 'prices' [for deriving economic implications such as resource misallocation, supply elasticity, etc.] are 85% of the average values for the index 'price of *nonfarm labor*, 1947–49 = 100' " [italics added] (fn. 2). In effect, their procedure means that one set of prices should be used to determine expenditures on the input and another to reflect its cost when calculating optimum input levels, etc. We contend that to use a nonfarm labor price in the derivations is inconsistent with their method for indirectly estimating labor's production elasticity, and this inconsistency is the cause of the large disequilibrium they found.[1]

Perhaps there is justification for arguing that the appropriate shadow price for all farm labor is greater than the nominal price of hired farm labor because of nonpecuniary benefits accruing to both hired and family labor, quality improvements in labor over time, and management skill of operator labor. But if a price equal to 85% of the nonfarm wage rate is the appropriate one for deriving optimum input levels, it is also appropriate for determining the labor factor share in order to obtain a reliable indirect estimate of labor's production elasticity.

It indeed may be that considerable disequilibrium existed in the agricultural sector during the period 1910–61, but the underlying properties of the Tyner and Tweeten model do not reveal it.[2]

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Tyner, F. H., and L. G. Tweeten. "Optimum Resource Allocation in U.S. Agriculture." *J. Farm Econ.* 48 (1966):613–31.

[1] Whenever the analyst assumes a set of conditions (e.g., prices) markedly different from those perceived by the economic actors, he is likely to conclude that the actors are less rational than they really are. In this particular case, the greater the difference in prices assumed between the two parts of the analysis, the greater the erroneous disequilibrium.

[2] Three additional minor points are (*a*) nominal output prices in our table 1 were computed in the same way as nominal input prices, i.e., by dividing Tyner and Tweeten's current dollar data (adjusted gross farm income) by their quantity data (farm output in constant dollars); (*b*) our derived equilibrium output in 1952–61 was slightly greater than output adjusted for government programs but less than actual output, and given a competitive industry and a negatively sloped demand curve, a downward shift in the supply function implies an increased, not decreased, output irrespective of the price elasticity of demand; and (*c*) if actual labor used is 168% of equilibrium labor, then labor is in excess supply by 68%, not 40%.

Books Reviewed

Cochrane, Willard W., and Mary E. Ryan. *American Farm Policy 1948–1973*. Minneapolis: University of Minnesota Press, 1976, xlv + 431 pp., $18.50.

As the authors note (p. 120), agricultural economists have the kind of skills that make them potentially useful to political practitioners, persons romantically but imprecisely called "policy decision makers." These skills when coupled with an interest in political activity have sometimes led agricultural economists into positions of direct participation in the political process, as in the case of Cochrane. Out of these experiences one is likely to be able to write an interesting review of the events of the era but not necessarily an insightful analysis of the political and economic systems. Cochrane and Ryan have written an easy-to-read account of the era and have compiled considerable legislative and commodity program detail. To a degree their work has the flavor of a personal saga. The other side of this coin is that the book is largely a tract for a particular political point of view in which neither the economic nor political analysis represents an advance in the professional literature. The review that follows is divided into three parts: a review of the order in which the issues are presented, some attention to the politics and public choice model that is used, and a listing of some of the issues amenable to economic analysis that are not resolved in the book.

Organization

The book is composed of three major sections. Part I contains four chapters that deal with the history of policy concepts, economic theory of supply and demand response, and a review of the legislative process. Part II is composed of four chapters containing various elements of the "historical record," and the two chapters of part III are devoted to an appraisal of the programs and a look to the future. A six-page glossary that introduces the major terms is presented at the front of the book.

Part I: Toward an Understanding of Farm Policy. In chapter 1, the "agroeconomic" setting of the twenty-five-year period is reviewed. In introducing the "facts," a number of theories related to factor use, sector growth, and income distribution are presented as if they were accepted propositions. They are used in the latter half of part II and in part III in justifying the conclusions of the authors. Chapter 2 contains an historical review of the broad political controversies of the era, while specific policies and programs are reviewed in chapter 3. These two chapters are reminiscent of Benedict's classic study of an earlier era, but in tone they are closer to Paarlberg's partisan description of the activities of seven secretaries of agriculture. Chapter 4 consists of a review of the legislative and administrative process. Because no formal model of political behavior is presented, it is difficult to determine if the space given to the Commodity Credit Corporation (CCC) reflects the author's admiration for its bureaucratic excellence or its considerable power to operate outside of the usual appropriation channels.

Part II: The Historical Record. Chapter 5 contains a usable compendium of the legislative acts, organized by the year of their passage. Although the organization of the material is unique, the bulk of it is available in various government publications, e.g., Agricultural Handbook No. 345 (USDA). Major commodity operations are presented in chapter 6 and represent something of an updating of Benedict and Stine. The program data have two minor flaws: (*a*) there is almost no attention to the special small farmer program provisions that may have influenced acreage diversion responses and the income distribution characteristics of the programs, and (*b*) hard-to-find materials are not referenced, making it difficult or impossible for later scholars to locate documents available to the authors. The program provisions summarized in chapter 6 are not formally related to the compendium in the previous chapter, so it is not easy to tie commodity program provisions to specific acts. Given the senior author's interest in quota programs, it is surprising that there is no space given to flue-cured tobacco, the most important quota program with transfer possibilities. The topics of land retirement, exports, and food programs presented in chapter 7 are useful, but students of individual topics will need to go to more detailed sources for fuller treatment, for example, Shepherd's treatment of the land retirement programs of the late 1950s. Chapter 8, program interrelationships and costs, contains the most complete accounting of treasury costs to be found anywhere currently.

Part III: Consequences and Appraisal. Chapter 9 is divided into four major topics: farm prices and incomes, resource allocation and efficiency, foreign trade, and consumer welfare. In each of the sections, hypotheses (theories) are presented as facts, and much of the relevant literature is not cited or utilized. Some of their empirical conclusions are suspect. For example, they conclude that prices were at or close to free market levels by 1965 (pp. 380, 390). Diversion programs affected output and prices at least through 1969 and probably through 1971. Thus, their estimates of consumer costs and producer benefits should be taken cautiously. Chapter 10 provides a short review of program benefits and a list of guidelines for future policy for-

mulation. The failure to specify rigorously a welfare model is apparent when in two adjoining paragraphs they conclude that the surpluses "literally gave life itself" and that the programs were costly because of "undue reliance on storage and surplus disposal programs" (p. 386). They call for a "concept of real social cost" (p. 391) that seems to reject consumer and producer surplus but turns instead on "vital interests of producers and consumers," implicitly assuming that inherent conflicts will somehow be resolved. The guidelines to the future are not useful because they are unspecific: storage stocks are needed but no holder is identified; flexibility is desirable but no mechanism is formulated; social "needs" are mentioned but no model is developed, etc.

Public Choice Questions

Books written about agricultural policy usually draw on political or public choice models as well as on economic models. In the present book, a number of public choice propositions are explicitly or implicitly put forward that are open to challenge or need fuller development. Several are presented as examples.

(*a*) Where should the initiative for formulating legislation lie: the Congress, the Secretary, or the Bureaucracy? In 1961 the Kennedy Administration proposed legislation to shift the initiative for farm legislation to the administration, leaving Congress the power to veto but not alter specific commodity programs. The proposal died in committee, but it is treated favorably by the authors in the sense that they explain that the agricultural sector is complex and problems are difficult to solve. Further, congressmen are presumed to not have the national interest in mind. If one generalizes from such reasoning, it is clear that all complex issues should be handled by the executive. In fact, the whole idea of representative government is called into question by this line of thought.

(*b*) How do contending forces work out their compromises most effectively? This question is addressed indirectly when the authors suggest that legislation cannot be developed on the floor of either house, leaving the main work to be done in committees. There is some evidence to suggest that committee decisions are important and that procedures (rules) that do not allow amendments on the floor speed up the legislative process. How then shall conflicts be resolved? The authors hint at a solution without addressing it fully: food and farm (consumer and producer) interests might be represented on one committee. Such a theory has important implications for the current organization of the U.S. Department of Agriculture. Food-aid programs and perhaps even "consumer protection" activities should be administered alongside commercial farm programs so that in each house of the Congress the compromises can be ground out in committee. Thus, the waning power of a small number of commercial farmers would be (is?) enhanced if their representatives have some power in committee over other legislation that is important to nonfarm representatives. What will happen to this power if food stamps are "cashed out" and the resources shifted to HEW? Who loses if commercial farm interests maximize their legislative power?

(*c*) What are the trade-offs in the use of alternative sources of funds to carry out program objectives? Congress may be reluctant to enact legislation that requires additional treasury outlays, particularly with the new congressional budgeting system. One obvious source of revenue for farmers is the consumer: if product quantities are restricted, market prices rise and farm incomes rise. In a sense, farmers unobtrusively collect the tax, which in the period studied may have been at about the rate of the average sales tax (Gardner and Hoover). Cochrane and Ryan discuss supply management, the euphemism for supply restraint, but never directly examine its role in the political acceptability of the programs. Another alternative is the expenditure of import duties. The praise of the CCC in chapter 4 probably should be reserved for section 32, which allows the secretary to use tariff proceeds to finance price support operations. Once the "surpluses" were accumulated, the secretary was empowered to give them to schools, institutions, and low-income households, removing any tell-tale evidence of price support. The reader interested in formal treatment of the political and economic principles involved in the choice among alternative devices used to transfer income will have to look elsewhere. This is a question that is intriguing and important if students of agricultural policy are to advance their understanding of the policy process.

(*d*) What is the relationship between price supports and votes in the next election? This public choice issue receives some attention in the book, but the treatment is not evenhanded. The authors describe political practitioners who frame and administer laws that win continuing assent as "practical." On the other hand, a preelection change in price support policy by Hardin and Butz is treated derisively. Since price support manipulation ("timing") is a tradition in both parties, its role in public decision making should be addressed formally and seriously. There is a question about how much income distribution through the Congress the citizens of the country can afford, given that each of us can afford to expend some resources (dead weight losses) to maintain the flow of funds from congressional action.

(*e*) Is completed political action the subject of analysis of conflicts and compromise or is it to be regarded as a frictionless revealer of the national will or the social welfare function? While many of their historical examples stress partisan fighting, governmental decisions are generally treated as

desirable. Such words and phrases as "we" in reference to federal legislation, "society," and "public interest point of view" lead toward reverence for rather than analysis of the process of public action. In preparing to sum up, the authors identify their position clearly when they ask if the "appraisal above is simply the judgment of two people, . . . worth no more than two votes" (p. 391). Not surprisingly, they conclude that their appraisal (all of it?) is judged to be correct when "The Congress of the United States confirmed year after year the need for price and income programs . . ." (p. 391).

Models, Analyses, and Assertions

As noted earlier there are a number of models presented as accepted facts at crucial points in the authors' arguments. It would take an inordinate amount of space to indicate the exact use of each proposition about which there is some doubt or need for additional evidence. Consequently, only the most important of the issues are listed with a brief indication of the role of each one in the authors' conclusions followed by a note in the nature of a question about the statement.

The role of the programs in increased agricultural productivity: the authors assert that output per unit of input grew because the programs reduced the amount of price uncertainty. To the extent that greater factor efficiency resulted, the real cost of the programs is less than reported amounts. Question: where are the empirical tests of the proposition? With price supports and program rules set politically, a new source of uncertainty was generated. On balance did farmers experience any change in the *ex ante* uncertainty they believed they were facing?

The role of the programs in generating the conditions that call for their continuation: the authors conclude that excess inputs at the end of World War II led to the set of programs to maintain product prices and not the other way around. They note that the programs may have prolonged the problem "depending on one's point of view" (p. 372), but they imply that the problem has decreased from the time of its recognition. Question: what was the role of the programs in discouraging migration, stimulating land development, and speeding research and extension dissemination of yield-increasing technology? The responses could have been substantial. One reading of the historical record is that farm programs generated one-third of net farm income over a two-decade period and that only with an unforeseen shift in export demand did the degree of "excess capacity" decline.

The role of the programs in firm-size growth: the authors argue that the programs helped the "fittest" to grow. They argue this would be another generally uncounted benefit arising from the programs because, implicitly, nonhuman factor efficiency is an important goal. Question: since no theory is developed that identifies the "fittest" before they grew, is not the statement tautological? *Ex post* it is necessarily true that those that grew were somehow the most successful or fittest. No data are brought to bear on the question, and no theory of firm growth is specified in a testable form. An interesting internal contradiction exists if one takes the initial problem to be one of the distribution of income. If the "fittest" were large, well-managed units and the programs helped them to grow, then the programs probably led to a concentration of income within the farm sector.

The role of the programs in raising farm incomes: the authors conclude that the farm programs were crucial in keeping farm incomes from falling in the past twenty-five years. Even with the programs, the "period 1948–73 was not a happy one." By implication the programs were the most important factor in farm income in the period. Question: were not other forces at work over this period that were more important in raising income of farm persons than were the farm programs? Off-farm sources of income of the farm population accounted for two-thirds of the advance in real per capita income between World War II and 1970 (U.S. Department of Commerce, pp. 225, 483). These sources grew at a little more than twice the rate of the growth in income from farming. Between 1942–46 and 1965–70 per capita income from farming of the farm population did not keep up with per capita nonfarm income, while the nonfarm sources of the farm population doubled relative to the income of nonfarmers.

The income distributional goals of the programs: by neglecting the issue the authors appear to believe that the income distribution of the program costs and benefits are unimportant in assessing the desirability of the programs. Average farm incomes would have been lower than they were in the absence of the program. Generally, incomes of farmers have been below nonfarmer incomes. Question: since income transferred through the market is in proportion to consumption, was not the food tax collected by farmers regressive on the payee side since poor people spend a larger percentage of their income on food than do the nonpoor? Were not the benefits concentrated among the upper half of the farm income distribution? In a redistributionist age, surely the average income of the losers and the gainers will not be taken as a sufficient guide to policy.

The goals of research and development expenditures by government: the authors conclude that a "subpolicy on agricultural resource use may need to be developed" if there is a period of "short food supply" (p. 397). Question: is not food always in "short supply," i.e., scarce? Is the land grant system such an important source of increased efficiency and so easily controlled by federal legislation that withholding funds can affect farm income in the short run? The general idea of restriction of research was close to a peak in 1956. Surely it was

not good public finance or economic analysis then, nor is it now.

Conclusion

No book can be expected to serve all possible purposes equally well. Many agricultural economists will find Cochrane and Ryan's book a useful place to begin their study of the post-World War II policy experience. This review has been directed to the identification of questions not resolved in the book, many of them still open for study and debate.

Dale Hoover
North Carolina State University

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Dahl, Dale C., and Jerome W. Hammond. *Market and Price Analysis: The Agricultural Industries*. New York: McGraw-Hill Book Co., 1977, xii + 323 pp., $13.95.

In this volume, the authors strive to enhance the readers' understanding of the economic organization and operation of the food and fiber sector of the U.S. economy. The authors attempt to fill a void in the subject matter areas of marketing and price analysis by treating both subjects comprehensively and analytically. The book is intended for use in introductory courses in marketing and price analysis; however, students should previously have had a course in microeconomic principles and college algebra.

Following the introductory chapter, a discussion of agricultural markets and marketing systems is presented in chapter 2. This discussion characterizes the marketing channels for the major products and inputs of U.S. agriculture. In the food retailing and wholesaling section, the authors incorrectly define a supermarket as a store with more than $500,000 annual sales when the current definition is twice that amount.

Some basic analytical tools of accounting, mathematics, and statistics are presented in chapter 3. Balance sheets, income statements, descriptive statistics, and index numbers are the principal items discussed. This chapter will be most valuable for students who have not had introductory courses in statistics and accounting.

Chapters 4, 5, and 6 contain a most competent presentation of the principles of price determination. Food consumption trends and elements of demand theory are presented in chapter 4. The chapter contains a comprehensive treatment of demand elasticities for farm products including an excellent application of these concepts to the analysis of demand for lamb. Chapter 5 discusses the concepts that underlie agricultural production and supply relations. This is a strong chapter that demonstrates the relationship between the production function, cost curves, and the supply curve. The discussion in the last part of this chapter focuses on the elasticity of supply and long-term trends in output and productivity of U.S. agriculture. The process of price determination in a competitive market and adjustment to price changes and price movements in agricultural markets are the subject of chapter 6. The chapter contains a good discussion of price trends, cyclical and seasonal patterns, and price discovery mechanisms for agricultural products.

The next four chapters focus on price differences and price variability. A thorough coverage of marketing margins for farm products comprises chapter 7. The spatial organization of markets in chapter 8 is one of the best chapters in the book. It is an excellent example of the way in which the authors have successfully applied economic principles to the analysis of agricultural problems. The discussion of price differences through time in chapter 9 focuses on storage and the futures market. This chapter needs considerable expansion and improvement; for example, the discussion of hedging and speculating in the futures market is inadequate. More illustrations of alternative positions are needed as well. The one illustration of a hedge that is presented needs improvement. More information on basis and basis movements is required, since this concept is so important to the use of the futures market. Finally, a section discussing the controversy surrounding the futures markets would be appropriate.

Quality differences and grades for farm products are discussed in chapter 10, as well as the advantages and disadvantages associated with a grading system. The last section of this chapter, which identifies the problems of using grades, would be

enhanced by a discussion of the recent controversy in grain grading and quality. Market information, discussed in chapter 11, focuses on market news, market outlook, and advertising. The section on generic advertising and check-off legislation is an interesting part of this chapter.

Chapter 12 defines the types of market structures that exist in our economy and presents an example of each type as it is found in the food and fiber system. This chapter is somewhat disappointing because it fails to discuss the industrial organization theory so widely used in agricultural economics. The market structure-conduct-performance paradigm would be a valuable addition to this chapter.

The presentation of marketing and pricing institutions in chapter 13 focuses on cooperatives and market orders. This chapter contains an excellent discussion of the characteristics of these institutions, their economic importance, and impact on agricultural markets. Chapter 14, market and price policy, focuses on the goals of agricultural marketing policy in terms of the competitive norm and why marketing activity differs from this competitive norm. The last chapter, chapter 15, discusses marketing and economic development. This chapter presents a brief overview of product and input market problems in developing countries. This brief chapter does not fit the general orientation of the rest of the book and will probably not provide students with any real understanding of an important but very complex topic. The chapter should be retained in future editions only if it is considerably enhanced.

A weakness of the text for some users is the lack of any specialized commodity or food retailing and wholesaling chapters. The book would have to be supplemented with outside materials for those users who desire more detail on a particular commodity, a group of commodities, or food wholesaling and retailing.

Market and Price Analysis is, overall, a well-written and organized text. It is appropriate for an introductory course in market and price analysis. This text provides students with an understanding of the economic organization and operation of the U.S. food and fiber system. An important strength of the text is the extensive application of economic principles to analysis of agricultural marketing problems. This use and application of theory far excels that found in any other introductory agricultural marketing textbook.

Donald W. Larson
The Ohio State University

Meyendorff, A. L. *Optimization of Farm Decisions through Marginal Analysis*. Moscow: Ekonomika, 1976, 39 kopeks

The basic contents of this new Soviet book would be familiar to any American undergraduate who has completed a course in intermediate price theory. Still, publication of this book should be of interest to western agricultural economists. Soviet publication for a wide audience of a broad framework of marginal analysis is quite novel. Additionally, it is interesting to see how a Soviet agricultural economist (with western training) relates this framework to Soviet agricultural policies and traditional modes of economic analysis. The author's discussion may be especially interesting for those westerners who have had contact with the latter, perhaps through recent East-West exchanges.

The book is an orderly introduction of terminology and progressively complex models. The exposition includes the familiar use of numerical examples, geometry, and algebra. The author first defines total, average, and marginal products and costs through the example of finding the optimal variable seeding rate for a farm producing wheat under fixed short-run conditions of diminishing returns. The author then proceeds to introduce isoquants, isocost lines, and marginal rates of factor substitution through the example of minimizing the cost of livestock rations. A final major section examines the farm's optimal structure of production—introducing product transformation curves, marginal rates of product transformation, and isorevenue lines.

These concepts are sufficiently foreign to warrant a prefatorial nod to the 1971 Party Congress's endorsement of optimal decision making and to early glimmerings of marginal analysis in the writings of Marx, Lyudogovsky of the prerevolutionary Petrovsky Agricultural Academy, and the 1920 writings of Studensky. The book's preface also mentions the native pioneering programming work of Kantorovich and Novozhilov. Meyendorff holds that neoclassical marginal analysis can be useful where the resources for programming are not available. He also maintains that marginal analysis illuminates the economic sense of certain decisions that may not be apparent under programming analysis.

In the book's first section, the traditional diagram of rising and falling product curves establishes three zones of rational and irrational input intensities. In the first "irrational" zone (in the range where the average product of the "variable" input is increasing), total output can be increased by simply using less of the "fixed" variable. This analysis is insightful, writes Meyendorff, for ongoing Soviet discussions of intensification, in particular for policies regarding the optimal size of the Soviet livestock herd given limited feed and the extension or retention of cultivation of some lands given limited capital goods.

The author illustrates the difference between average and marginal values with the avowed goal of concentrating attention upon information about increments specific enough to be useful. He feels that the propagation of marginalistic theory will promote the development of information useful for less aggregative planning.

A typical Soviet statistical study of "economic effectiveness" correlates production decisions (e.g., about intensification, specialization) with performance indicators of some sort (e.g., profit per hectare, per man, or per ruble invested) for a sample of farms or regions. These studies tend to recommend for all farms or regions those decisions employed on the "advanced" farms. Meyendorff criticizes this approach as one that slights differences in farming conditions, and he maintains the need for criteria for optimal decision making by farms in specific circumstances. Planning authorities should pass on to farm managers more general functional information for these decisions and fewer production norms.

Meyendorff points out that marginal analysis with its focus on functional relationships puts some order into otherwise confusing discussions. Standard planning discussions offer a plethora of (often hortatory) directives for farms (for example) to simultaneously minimize cost, maximize yields, and maximize profits. His simple examples show that these goals are generally logically incompatible.

In the Soviet Union at the present time, some farms may receive several times the price paid farms in other price zones. In such a situation, decentralized profit maximization cannot lead to a socially optimal distribution of production. The author briefly acknowledges this special circumstance of Soviet markets, as well as the fact of rationed inputs and compulsory sales plans. He does direct his analysis to make a comment on government pricing of farm inputs. However, the author does not go on, for instance, to bring to bear the tools he has developed to make an analytic contribution to the now old discussion of Soviet price zoning, differential rent, and efficient specialization.

As also happens in college courses, time limits apparently intervene before this book gets to the last chapters of the price theory course. Despite this, neoclassical production theory is apparently thought useful for Soviet circumstances. Of the 18,000 copies released in spring 1976, none were to be found in Moscow book stores in the late summer.

Kenneth R. Gray
Moscow Timiriazev Agricultural Academy and *University of the South*

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Fox, James J. *Harvest of the Palm: Ecological Change in Eastern Indonesia.* Cambridge, Mass.: Harvard University Press, 1977, xv + 290 pp., $15.00.

Kneese, Allen V. *Economics and the Environment.* New York: Penguin Books, 1977, 285 pp., $3.50.

McDiarmid, John Orville. *Unskilled Labor for Development—Its Economic Cost.* Baltimore, Md.: Johns Hopkins University Press, 1977, xii + 206 pp., $12.50, $4.50 paper.

Mosher, Arthur T. *Thinking About Rural Development.* New York: Agricultural Development Council, 1976, xii + 350 pp., price unknown.

Organisation for Economic Co-Operation and Development. *Economics of Transfrontier Pollution.* Paris: Organisation for Economic Co-Operation and Development, 1976, 218 pp., $10.00.

Pollard, J. H. *A Handbook of Numerical and Statistical Techniques with Examples Taken Mainly from the Life Sciences.* New York: Cambridge University Press, 1977, xvi + 349 pp., $24.95.

Smith, Eldon D. *Industrialization of Rural Areas.* Mississippi State: Southern Rural Development Center, Rural Development Bibliography Series No. 1, 1977, 148 pp., $5.00.

Tisdell, C. A., and P. W. McDonald. *Economics of Fibre Markets.* New South Wales, Australia: The University of Newcastle, 1977, vii + 244 pp., $8.80.

U.S. Council of Economic Quality. *Untaxing Open Space: An Evaluation of the Effectiveness of Differential Assessment of Farms and Open Space.* Washington, D.C.: U.S. Government Printing Office, April 1976, xiii + 401 pp., $5.40.

Wright, Forrest B. *Rural Water Supply and Sanitation.* Huntington, New York: Robert E. Krieger Publishing Co., 1977, xiii + 305 pp., $16.50.

Announcements

1977 Meeting Allied Social Sciences Association

The American Agricultural Economics Association will meet jointly with the Allied Social Sciences Association in New York, New York, 27–30 December 1977. Sessions are being scheduled as follows: (*a*) Contemporary Issues in Resource Economics; Emery N. Castle, Resources for the Future, chairman; (*b*) Agricultural and Food Policy Making—Concerns, Forces, Participants (a round table discussion); R. G. F. Spitze, University of Illinois, chairman; (*c*) Appropriate Technology for U.S. Agriculture: Are Small Farms the Coming Thing?; Otto C. Doering III, Purdue University, chairman; (*d*) The Economics of Rural Household Behavior; W. Keith Bryant, Cornell University, chairman. Program details are available from the AAEA president at the following address: R. J. Hildreth, Farm Foundation, 1211 West 22nd Street, Oak Brook, Illinois 60521.

Nominating Committee

R. J. Hildreth, president of the American Agricultural Economics Association, has appointed the following persons to the nominating committee: Kenneth Farrell, ERS, USDA, chairman; Richard King, North Carolina State University; Glenn C. Himes, Ohio State University; Eugene E. Gerke, Super Market Institute, Inc.; A. M. Weisblat, Agricultural Development Council, Inc.; Fred D. Sobering, Kansas State University; B. D. Gardner, University of California, Berkeley; and C. E. Willis, University of Massachusetts. This committee will nominate two persons for the office of president-elect and two sets of two paired candidates for directors of the Association. Individual members of the Association should submit their suggested nominees to Kenneth Farrell, Economic Research Service, U.S. Department of Agriculture, 500 12th St., S.W., Washington, D.C. 20250, by 10 December 1977.

Oral History Memoir Available

An oral history memoir with Harry R. Wellman, professor of agricultural economics, emeritus, has been completed by the Regional Oral History Office of The Bancroft Library, University of California, Berkeley. Wellman was Giannini Foundation director, 1942–52. The bound and indexed manuscript with an introduction by Chester McCorkle, Jr., and Herman T. Spieth is available for research at The Bancroft Library and at UCLA. Copies are available to other depositories at $30.00. For further information, write the Regional Oral History Office, Room 486 The General Library, University of California, Berkeley 94720.

AAEA Awards Program

Through its awards program the American Agricultural Economics Association recognizes professional excellence in several subfields of agricultural economics. The AAEA recognizes professional achievement at the student, the young professional, and the more experienced levels in research, teaching, and extension activities. Seventeen awards will be presented in 1978.

The program has a rich tradition as can readily be noted by a review of the roster of award winners over the years. The AAEA believes that this tradition will be continued in the 1978 program.

The 1978 program has been organized and will be conducted by committees representing a substantial professional input of nearly 100 committee members. We hope you will submit nominations for the categories outlined in this announcement. The general awards chairman is A. Gordon Ball, College of Agriculture, University of Guelph, Guelph, Canada N1G 2W1, telephone (519) 824-4120, ext. 2284 or 2285.

Distinguished Extension Programs

The distinguished extension program awards recognize achievement of excellence in extension economics teaching programs. Two awards are offered in 1978. One award will be given to an individual with less than ten years experience in extension education, and the other award will go to an individual with ten or more years of experience in extension education.

Nomination. Nominations may be made by any member(s) of the AAEA, and selection will be made from among those nominated. The nominee must have been active in extension teaching for at least one year at the time of the nomination, and the content of teaching efforts must be principally in the field of agricultural economics. Each nomination must be made by separate letter accompanied by eight copies of documentary evidence indicating nominee's name and extension title; extension program area in which teaching is conducted; identification of the clientele served; objectives of the educational program; teaching techniques, educational methods, and materials utilized; and effec-

tiveness of the extension teaching effort in terms of clientele response and/or establishment of the utility of the extension teaching program.

Evaluation. Each nominee will be evaluated on the quality of work as indicated by the documentary evidence submitted with the nomination relative to the following characteristics: effectiveness in teaching application of economic principles and tools of analysis appropriate to the problem and audience involved; ability to conceptualize new extension educational programs and application of new teaching concepts to existing programs; effectiveness in bringing about significant behavioral change and/or understanding of clientele; and contribution to improved extension teaching in agricultural economics as evidenced by participation in appropriate professional activities and organizations.

Due dates. Nominations and supporting evidence must be submitted by 1 February 1978 to the subcommittee chairman: Robert J. Bevins, Department of Agricultural Economics, University of Missouri, Columbia, Missouri 65201. Recommendations of the subcommittee will be forwarded to the general awards chairman by 15 May 1978.

Distinguished Policy Contribution

The distinguished policy contribution award recognizes an outstanding contribution to policy decisions or to the advancement of public understanding of major policy issues related to food, fiber, agriculture, and human welfare. Policy issues are interpreted in their broadest sense. They may relate to either a national or international situation. Their focus may be on production, marketing, or consumption. They include such things as price and income policy, environment and land-use issues, local government, rural poverty, and community development problems. The purpose of the award is to encourage interest in economic analysis of public policy issues that can provide timely and relevant information for more effective public policy and program decisions. The award is intended to focus attention on important efforts in research, education, or public service that facilitate the policy process and improve public performance and understanding. It may be given annually.

Nominations. Nominations may be submitted by individuals, groups, or institutions. In addition, the Distinguished Policy Contribution Award Committee is encouraged to generate nominations to assure that all outstanding policy contributions are considered. Winners will be selected on the basis of the supportive material showing major contributions within the previous five years. Renominations are invited provided the supportive material is updated. Each nomination must be made by separate letter accompanied by documentary evidence supporting the nominee's contributions to the development and/or understanding of public policy. Eight copies of each entry should be submitted. Return of the material submitted is not customary but can be requested.

Evaluation. Entries must demonstrate significant contributions to the development and/or understanding of policy through research, extension, education, or public service activities. They will be evaluated on the quality of contribution to policy decisions or to the advancement of public understanding of major policy issues related to food, fiber, agriculture, and human welfare. Additionally, contributions will be evaluated based on the impacts they have had on the decision-making process. The effort must be a significant contribution to policy understanding as indicated by publication, program participation, or public response and awareness. The work should show evidence of demonstrated excellence in defining and articulating policy issues to the public and helping the public to understand and be aware of such issues.

Due Dates. All nominations and documentation should be sent by 1 February 1978 to the chairman of the distinguished policy contributions award subcommittee: J. Edwin Faris, Department of Agricultural Economics and Rural Sociology, Clemson University, Clemson, South Carolina 29631. Recommendations of the subcommittee will be forwarded to the general awards committee chairman by 15 May 1978.

Distinguished Undergraduate Teaching

The distinguished undergraduate teaching awards recognize and encourage meritorious performance in undergraduate teaching in agricultural economics. Two awards will be given: one for an individual with less than ten years of experience as an undergraduate teacher, and one for an individual with ten or more years of experience as an undergraduate teacher.

Nomination. Nominations may be submitted by any member(s) of AAEA. Winners will be selected based entirely on the supportive material submitted. Renominations are invited providing the supporting evidence is updated and resubmitted. Nominees must be actively engaged in teaching at a professional level during the 1977–78 school year. Nominees must have demonstrated outstanding ability as an undergraduate teacher of agricultural economics. The format of the nomination material submitted should use as primary categories the five major criteria areas listed in the evaluation criteria section that follows. Include biographical data of the nominee—name, present position, education, and number of years of university-college teaching and experience in the profession. Supporting evi-

dence must be limited to three pages for each of the five primary categories of the nomination. No more than three letters of reference from peers and students for each of the five primary categories should be included. Adjunct material may be included as an appendage to the nomination package if desired, for example, summaries of student class evaluations for courses taught. Eight copies of each nomination package are required.

Evaluation. Five major criteria areas will be used in evaluating nominations with relative weights as follows. (*a*) Quality of teaching (45%)—ability to motivate and stimulate student to learn (20%); innovation for presentation, evaluation measurements (15%); and mastery of subject, use, and application to business conditions (10%). (*b*) Academic advising, counseling, and extracurricular activities of students (20%)—advising and counseling (14%); and catalyzing extracurricular activities of students, i.e., department clubs or organizations, student council or senate, student publications, convocations, seminars, community involvement (6%). (*c*) Campus participation in instructional, course, and curricular improvement efforts (15%)—department, college, and university-wide. (*d*) Professional improvement in teaching for benefit of self and peers (15%)—published textbooks, manuals, bulletins (5%); research papers related to improved teaching (5%); and participation in professional meetings and committees related to improved teaching and student activities (5%). (*e*) Department/college/university teaching awards (5%)—student association/alumni awards.

Due dates. Nominations and supporting evidence must be sent by 1 February 1978 to the chairman of the distinguished undergraduate teaching awards subcommittee: John D. Helmberger, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, Minnesota 55108. Recommendations of the subcommittee will be forwarded to the general awards chairman by 15 May 1978.

Outstanding Master's Degree Program

The outstanding master's degree program awards have as their objective development of professional excellence by individuals pursuing master's degree programs in agricultural economics. Three awards are offered. A cash supplement of $250 accompanies each award.

Nomination. Any department engaged in training agricultural economists at the master's degree level may submit nominations. Entries must be submitted by the head of the department where the degree is earned. A department may submit one nomination for each fifteen master's degree candidates or fraction thereof presented to a graduate school faculty during the year. To determine the number of eligible candidates, departments should limit consideration to candidates who will receive a degree in agricultural economics and to candidates who have taken agricultural economics as a field of emphasis. Nominations should include thesis or other comparable documentation. Selection will be made from documentation approved in final form by the student's advisory committee during the calendar year 1977, provided the candidate has met all other formal requirements for the master's degree. A published thesis may be entered in both the published research and master's program classes but will be eligible for only one award. Although a published thesis is acceptable, a copy of the thesis as submitted to the graduate faculty should be sent whenever possible. Three copies of all nomination materials (i.e., thesis) are required to be sent to the committee chairman. All copies will be returned after reading by the judges.

Evaluation. Copies of evaluation criteria may be obtained from the chairman of the subcommittee.

Due dates. All nominations and documentation should be sent by 1 February 1978 to the chairman of the outstanding master's degree award subcommittee: Larry J. Martin, School of Agricultural Economics and Extension Education, University of Guelph, Guelph, Ontario, Canada N1G 2W1. Recommendations of the subcommittee will be forwarded to the general awards committee chairman by 15 May 1978.

Outstanding Doctoral Degree Program Award

The outstanding doctoral program awards are given in recognition of development of professional excellence for persons pursuing a doctoral program in agricultural economics. Three awards will be given in 1978. A cash supplement of $250 accompanies each award.

Nomination. Entries must be submitted by the head of the department where the thesis or comparable document was presented in partial fulfillment of requirements for a degree. A department may submit one nomination for each twelve doctoral candidates or fraction thereof presented in agricultural economics to a graduate school faculty during the year. To determine the number of eligible nominations, departments should limit consideration to candidates who received a degree in agricultural economics and to candidates who have taken agricultural economics as a field of emphasis. Selection will be made from theses (or comparable documents) approved in final form by the student's advisory committee during the calendar year 1977, provided the candidate has met all other formal requirements for the doctoral degree. A published thesis may be entered in both the published research and thesis categories but will be eligible for

only one award. Although a published thesis is acceptable, a copy of the thesis as submitted to the graduate faculty should be sent whenever possible. Three copies of a thesis must be sent to the subcommittee chairman. All copies will be returned after they have been read by the judges.

Evaluation. Criteria for evaluation of nominations may be obtained from the chairman of the subcommittee.

Due dates. Nominations and supporting evidence should be sent by 1 February 1978 to the chairman of the outstanding doctoral thesis award subcommittee: Terrence F. Glover, Department of Economics, UMC 35, Utah State University, Logan, Utah 84322. Recommendations of the subcommittee will be forwarded to the general awards chairman by 15 May 1978.

Quality of Research Discovery

This and the following three awards are given to encourage excellence in publications in all areas of agricultural economics.

Rules. There are no requirements regarding the number of authors or professional experience. Nominations may be submitted by individuals, departments, or agencies. Nine copies of each publication should be submitted, unless expense for the individual is excessive. Return of the publications is not customary but can be requested. Nominations should be submitted for only one award in either the quality of research discovery or quality of communication category for 1977.

Nomination. A maximum of two awards are given. Entries must specify that the nomination is to be judged for the quality of research discovery. Entries must have been published in 1977.

Evaluation. The research must be a significant contribution to the field of knowledge in agricultural economics. The work should demonstrate excellence in research methodology and may deal with conceptualization of researchable problems as well as empirical verification.

Due dates. Entries should be sent by 1 February 1978 to the subcommittee chairman: Irving Dubov, Department of Agricultural Economics and Rural Sociology, University of Tennessee, Knoxville, Tennessee 37901. Recommendations of the subcommittee will be forwarded to the general awards chairman by 15 May 1978.

Quality of Communication

The rules pertaining to the award for quality of research discovery also apply to this award for quality of communication.

Nomination. A maximum of two awards will be given. Entries must specify that the entry is to be judged for its quality of communication. Entries must have been published in 1977.

Evaluation. Entries must demonstrate superior communication of concepts or knowledge in any subject matter area or professional specialization (i.e., research, teaching, or extension) in agricultural economics to a specified audience. If dealing with transmission of research findings, the publication need not contain the author's original research but should improve communication within the profession as well as between it and other professions.

Due dates. Entries should be forwarded by 1 February 1978 to the subcommittee chairman: Irving Dubov, Department of Agricultural Economics and Rural Sociology, University of Tennessee, Knoxville, Tennessee 37901. Recommendations of the committee will be forwarded to the general awards chairman by 15 May 1978.

Publication of Enduring Quality

One award is offered for a publication with a publication date during the fifteen-year period 1953–67. Entries are judged on the basis of the enduring quality of their contribution to the profession.

Eligible entries are articles in this *Journal* (during part of the period considered, the *Journal* was known as the *Journal of Farm Economics*) regardless of whether the authors are AAEA members and also other publications by authors, one of whom was a member of the AAEA at the time of publication. Entries must be submitted by departments or other administrative units, colleagues, or the authors themselves. Publications receiving an award in any other category in previous years are eligible for this award.

Entries should be sent by 1 February 1978 to the subcommittee chairman: A. H. Harrington, Department of Agricultural Economics, Washington State University, Pullman, Washington 99163. Nine copies of the publication should accompany the entry. Recommendations will be forwarded to the general awards chairman by 15 May 1978.

Outstanding Journal *Article*

The editor and editorial council of the *Journal,* with the editor as chairman, will choose the outstanding article in the 1977 volume of the *Journal.*

AAEA Fellow

Nominations for AAEA Fellow should be sent to the secretary-treasurer, John C. Redman, University of Kentucky, Lexington, by 1 December 1977. Any living AAEA member may be nominated. Those submitting nominations should be prepared to submit upon request biographical information in support of the nominee.

General Recognition

Awards will be presented at the annual AAEA awards program during the annual meeting at Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 6–9 August 1978. Winners will be identified in the annual meeting awards program brochure and in the December proceedings issue of the *Journal*.

Personnel

University of Arkansas

Appointments: George L. Greaser, Ph.D. Virginia Polytechnic Institute and State University, is an assistant professor; **Robert N. Shulstad,** assistant professor, is editor of the *Southern Journal of Agricultural Economics,* 1978–80.
Retirement: William J. Windham, former assistant professor, after 26 years of service.
Honor: J. Martin Redfern, associate professor, received the Outstanding Faculty Member Award for 1976–77.

University of California, Davis

Leave: Gordon A. King, professor, is on sabbatical leave at Cornell University through Feb. 1978.

University of Chicago

Appointment: Theodore W. Schultz, professor emeritus, is chairman of the Social Science Section, National Academy of Science.
Honor: D. Gale Johnson, professor, is a fellow of the American Academy of Arts and Sciences.

Clemson University

Appointments: Eddie H. Kaiser, Ph.D. Iowa State University, is an assistant professor in agricultural finance; **Stephen E. Miller,** Ph.D. Virginia Polytechnic Institute and State University, is an assistant professor in agribusiness management; **James L. Novak,** M.S. University of New Hampshire, is a visiting instructor in Florence, South Carolina; **Gary J. Wells,** Ph.D. North Carolina State University, is an assistant professor in interregional competition and trade.
Retirements: Lewis D. Malphrus is an associate professor emeritus after 31 years of service; **James M. Stepp** is an alumni professor emeritus after 36 years of service.

Colorado State University

Appointments: Jerry B. Eckert, assistant professor, is the chief of party with the CSU/Lesotho Agricultural Sector Analysis team, Maseru, Lesotho; **Kenneth L. Leathers,** Ph.D. Colorado State University, is on a two-year assignment with the CSU/LASA team, Maseru, Lesotho.
Leave: Charles W. Howe, professor of economics, is the Hill visiting professor of natural resource economics, University of Minnesota, academic year 1977–78.
Returns: Rex D. Rehnberg, professor, is back on full-time duty after serving half-time for two years as university mediation officer; **Robert A. Young,** professor, is back from a research assignment with the Department of Farm Management, Lincoln College, Canterbury, New Zealand.
Resignation: Sam H. Johnson, III, formerly with the CSU Water Management Research Party, Pakistan, is with the Ford Foundation team, Bangkok, Thailand.
Honor: S. Lee Gray received the Oliver P. Pennock Award for excellence in teaching.

University of Connecticut

Appointment: Joseph Diamond, Ph.D. Michigan State University, is an assistant professor of community development.
Leave: T. C. Lee, professor, is on sabbatical leave at the University of Georgia for one academic year.
Return: Carlos Stern, associate professor, is back from the U.S. Geological Survey, Reston, Virginia.
Retirement: Arthur W. Dewey is a professor emeritus after 30 years of service.

Cornell University

Appointment: Gerald White, Ph.D. The Pennsylvania State University, is an assistant professor in production economics.
Leaves: Richard N. Boisvert, associate professor, is on leave with the Federal Insurance Administration, Department of Housing and Urban Development, Washington, D.C., until August 1978; **Duane Chapman,** associate professor, is a visiting associate professor for the Energy and Resource Program, University of California, Berkeley, through June 1978.
Honor: Wendell G. Earle, professor of marketing, received the Professor of Merit Award for 1977 for excellence in classroom teaching, advising, and contribution to undergraduate programs.

University of Florida

Appointments: James R. Simpson, formerly with Texas A&M University, is an associate professor in livestock marketing; **Thomas S. Walker,** formerly with Stanford University, is an assistant research scientist under the UF/USAID program for technical assistance to El Salvador.

Return: J. Kamal Dow, associate professor, is back after serving as chief of party in Ecuador for five years.

University of Idaho

Appointments: Stephen Smith, Ph.D. University of Wisconsin, and **David Walker,** Ph.D. Iowa State University, are assistant professors of resource economics.
Leave: Gerald Marousek, professor, was a visiting professor, New Mexico State University, fall 1976, and is a visiting professor, University of New England, Armidale, Australia, through August 1977.

University of Illinois

Appointments: Bruce L. Dixon, Ph.D. University of California, Davis, and **Philip Garcia,** Ph.D. Cornell University, are assistant professors; **Roger E. Schneider,** Ph.D. University of Missouri, is a research associate.
Leaves: Emer E. Broadbent, professor, is on sabbatical leave for six months through Nov. 1977; **George G. Judge** is on leave of absence at the University of Georgia through May 1978; **J. W. Robinson** is on sabbatical leave for one year, ending in July 1978.
Honor: Lowell D. Hill was named the first Laurence J. Norton Professor of Agricultural Marketing.

Iowa State University

Appointment: John T. Scott, professor of economics, is Coordinator of International Programs, College of Agriculture.
Honor: Earl O. Heady, professor of economics and distinguished professor in agriculture, received a citation from the ISU Alumni Association in recognition of long and outstanding service.

Kansas State University

Appointments: George Brandsberg, formerly with Creative Services, Des Moines, Iowa, is assistant extension editor; **Barry Childs,** M.S. Kansas State University, is an area extension economist in Concordia; **Harold Lobmeyer,** M.S. Kansas State University, is an area extension economist in Garden City; **Barry L. Flinchbaugh,** former extension economist, public affairs, is the assistant to the president of KSU in charge of public affairs, information, and development.
Resignation: Fred Delano, former area extension economist in Baldwin City, is vice-president, Lawrence National Bank, Kansas.

University of Kentucky

Leave: Garnett L. Bradford, professor, is a visiting professor, University of Minnesota, academic year 1977–78.

Michigan State University

Appointments: Vince Barrett and **Greg Lassiter** are specialists with the Upper Volta Project; **Philip G. Favero** is a temporary assistant professor with the public affairs program; **Thomas Stickley** is a temporary associate professor with the Upper Volta Project; **David Wilcock** is a temporary assistant professor and chief of party with the Upper Volta Project.
Honor: Herb Kriesel, professor, is a member of the eighteen-person Joint Advisory Committee to the Directors General of the FAO, ILO, and UNESCO on agricultural science, education, and training.

University of Minnesota

Appointments: Paul Gallagher, formerly with the CED, ERS, USDA; **Richard J. Magnani,** M.S. University of Minnesota, is a research specialist in marketing structure and performance.
Leave: Mathew D. Shane, associate professor, is on sabbatical leave to do research on Malaysian development and trade, University Pertanian, Malaysia, through June 1978.
Resignation: Martin E. Abel, professor, is vice-president of Schnittker Associates, Washington, D.C.

Mississippi State University

Appointment: Charles E. Powe, Jr., formerly with the Farmer Cooperative Service, USDA, is an assistant professor and assistant agricultural economist.

Oregon State University

Appointments: James K. Whittaker, former assistant professor, Purdue University, is an assistant professor in agricultural production economics; **Russell C. Youmans,** professor, is director of the Western Rural Development Center.
Leaves: James B. Fitch, associate professor, is an agricultural project specialist with the Ford Foundation in Cairo, Egypt; **R. Bruce Rettig,** associate professor, is on sabbatical leave at the University of Washington and the National Marine Fisheries Service office, Seattle, until August 1978.
Resignation: George L. Wyatt, former assistant professor, is with the Oregon College of Education, Monmouth.

Pennsylvania State University

Appointments: Dan E. Moore is an assistant professor of rural sociology; **Robert D. Weaver** is an assistant professor.
Return: Milton C. Hallbert, professor, is back after five months as a visiting professor, Oklahoma State University.

Purdue University

Appointments: James K. Binkley, Ph.D. Virginia Polytechnic Institute and State University, **Robert D. Boynton,** Ph.D. Michigan State University, **Jon A. Brandt,** Ph.D. University of California, Davis, **Craig L. Dobbins,** Ph.D. Oklahoma State University, and **John Spriggs,** Ph.D. University of Minnesota, are assistant professors; **Paul N. Blick,** M.S. Purdue University, is a temporary instructor; **Martin T. Pond** is assistant director for community resource development, Indiana Cooperative Extension Service; **G. Edward Schuh,** professor, is director, Purdue University Center of Public Policy and Public Administration; **Thomas K. White,** professor, is acting director, International Programs in Agriculture and International Education and Research.
Resignation: Mario Coria-Salas is head, Graduate Department of the School of Economics, National Polytechnic Institute, Mexico City.
Honor: G. Edward Schuh, professor, was elected a fellow of the American Academy of Arts and Sciences.

University of Rhode Island

Leave: Virgil Norton, professor, is studying at the University of Maryland.

Rutgers—The State University

Resignation: William L. Park, former professor of agricultural economics and marketing, is the agricultural economics department chairman, Brigham Young University.

University of Tennessee

Appointment: B. H. Pentecost, formerly with the Development Office, is a professor in agricultural law.

Texas A&M University

Return: Ray Billingsley, professor, is back from a two-year United Nations assignment in Thailand.

U.S. Department of Agriculture

Appointments: William T. Boehm, formerly with the Virginia Polytechnic Institute and State University, is with the Consumer Economics and Demand Analysis Program Area, NEAD; **Linda Kay Lee,** Ph.D. Iowa State University, is with the Resource Inventories and Use Program Area, NRED; **Dean Richards,** M.S. Texas A&M University, is with NEAD; **Tanya Roberts,** former consultant in private industry, is with the Structure and Adjustments Program Area, NEAD; **Debra Waldon** is with the Resources Systems and Productivity Analysis staff, NRED.
Appointments in CED: Robert W. Bohall is deputy director; **William H. Meyers,** Ph.D. University of Minnesota, and **Robert D. Remmele,** Ph.D. Iowa State University, are with the Forecast Support Group; **John G. Stovall** is director.
Appointments in EDD: Susan D. Brown, William F. Fox, Wanda Godsey, and **Patrick Sullivan** are with the State and Local Government Program Area; **James Cantwell** and **Peggy Ross** are with the Health and Education Program Area; **Irma Elo** is a social science analyst with the Health and Education Program Area.
Reassignments: Robert I. Coltrane, leader, Manpower Program Area, EDD, is on a one-year assignment to work with the National Commission of Manpower Policy, Washington, D.C.; **William Crosswhite,** assistant director, NRED, is on a one-year study program at Vanderbilt University; **Eric Oswald,** formerly with the Soil Conservation Service, is with the Environmental Studies staff, NRED, Tucson, Arizona.
Resignations: Joseph Combs, formerly with the Fruits, Vegetables, Sweeteners, and Tobacco Program Area, CED, is studying at Massachusetts Institute of Technology; **Gary A. Davis,** formerly with the Meat Animals Program Area, CED, Lansing, Michigan, is with a private consulting firm; **Gary G. Frank,** formerly with the Dairy Program Area, CED, returns to farming in Wisconsin; **Duane Paul,** formerly with the Environmental Studies staff, NRED, is with Chase Econometrics, Philadelphia; **Linda Zygaldo,** formerly with NRED, is with the Environmental Protection Agency, Washington, D.C.
Retirements: Harold Ellis, formerly with the Resource Organization and Control Program Area, NRED, after 30 years of federal service; **Norman D. Kimball,** formerly with the Small Watershed staff, NRED, after 29 years of federal service.
Honors: Arvin R. Bunker, with NEAD, received one of three awards in a competition sponsored by *The Logistics and Transportation Review,* University of British Columbia; **Dan Colacicco,** with the Environmental Studies staff, NRED, was a member of a research team receiving a USDA Superior Service Award for research on land utilization of sewage sludge.

Utah State University

Appointment: Basudeb Biswas, Ph.D. University of Chicago; **Bruce Godfrey,** former associate professor of forest and range resource economics, University of Idaho, is an associate professor.

Virginia Polytechnic Institute and State University

Appointment: Kenneth H. Baum, Ph.D. Iowa State University, is an assistant professor.

Washington State University

Leaves: Smith Greig, professor, is on leave for one year with the USAID, Washington, D.C.; **Don West,** associate professor, is on leave for one year with the Food and Nutrition Service, Washington, D.C.

Other Appointments

Kamel S. Al-Ani, Ph.D. Pennsylvania State University, is an economist with the Ministry of Agriculture, Baghdad, Iraq.
Jeffrey Doutt, Ph.D. University of California, Berkeley, is the chairman, Department of Management, Sonoma State College.
Richard Dowell, Ph.D. University of Chicago, is in Sydney, Australia.
Raymundo E. Fonollera, Ph.D. Oregon State University, is vice-president for Resources Development and Planning, Central Mindanao University, Philippines.
Edward M. Jones, Jr., M.S. Virginia Polytechnic Institute and State University, is with the Federal-State Crop Reporting Service, Louisville, Kentucky.
James A. Mize, Jr., M.S. Virginia Polytechnic Institute and State University, is with Resources for the Future, Washington, D.C.
Richard E. Nellis, Jr., former lecturer, Lyroming College, is a staff economist with the Pennsylvania Public Utility Commission.
Leslie Nieves, M.S. Virginia Polytechnic Institute and State University, is with Battelle Pacific Northwest Laboratory, Richland, Washington.
Todd Petzel, Ph.D. University of Chicago, is with Macalester College.
Randall Pope, M.S. University of Arkansas, is with the Prudential Insurance Company, Little Rock, Arizona.
Vasant Suhkatme, Ph.D. University of Chicago, is an economist, World Bank.
Daniel Sumner, Ph.D. University of Chicago, is with the RAND Corporation.
J. Karl Wise, Ph.D. Pennsylvania State University, is a staff economist with the American Veterinary Medical Association, Schaumburg, Illinois.

Obituary

Harry M. Love

Harry M. Love died on 21 June 1977 in Blacksburg, Virginia. He had retired as head of the Agricultural Economics Department, Virginia Polytechnic Institute and State University, ten years previously as professor emeritus.

He was born in Virginia in 1902 and received his undergraduate education at Virginia Polytechnic Institute and State University and his Ph.D. at Cornell University. He taught vocational agriculture in Virginia public schools and was employed by the Farm Credit System before returning to his alma mater in 1938 as a member of the agricultural economics faculty.

Love was a keen observer of life about him, impatient with faulty workmanship and incompetence, and absolutely intolerant of duplicity and dishonesty. His wit was keen and was used freely to illustrate a point or to attack a position he considered wrong or inferior. He was a strong advocate of traditional free-enterprise economics.

He is survived by his widow Elsie W. Love, two married daughters, and four grandchildren.

TENURED FACULTY POSITION
in the
Department of Agricultural and Resource Economics
College of Natural Resources

Title: Tenured level position in International Rural Economic Development.

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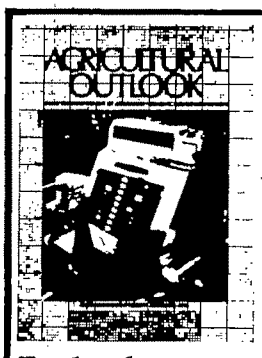
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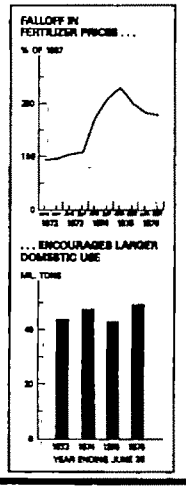
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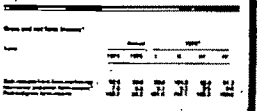
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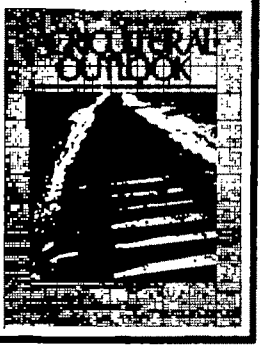
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Fellows, 1957–77

1957
John D. Black
Thomas N. Carver
Joseph S. Davis
Garnet W. Forster
Asher Hobson
Edwin G. Nourse
Theodore W. Schultz
Henry C. Taylor
Frederick V. Waugh
Milburn L. Wilson

1958
Mordecai J. B. Ezekiel
Oscar B. Jesness
William I. Myers

1959
Harold C. M. Case
Oscar C. Stine

1960
Leonard K. Elmhirst
Sherman E. Johnson

1961
Oris V. Wells
Ernest C. Young

1962
Murray R. Benedict
Hugh B. Price

1963
Raymond G. Bressler, Jr.
Earl O. Heady

1964
Joseph A. Ackerman
Karl Brandt
Foster F. Elliott

1965
Bushrod W. Allin
George H. Aull
Willard W. Cochrane

1966
J. Carroll Bottum
George E. Brandow
Forrest F. Hill

1967
D. Gale Johnson
William Hord Nicholls
Harry C. Trelogan

1968
John F. Booth
Maurice M. Kelso
Elmer Joseph Working

1969
Nathan M. Koffsky
James G. Maddox
Walter W. Wilcox

1970
Charles Edwin Bishop
Marion Clawson
Glenn Leroy Johnson

1971
D. Howard Doane
Don Paarlberg
Rainer Schickele

1972
Karl A. Fox

1973
Harold F. Breimyer
Kenneth H. Parsons
Lauren K. Soth

1974
Dale E. Hathaway
Vernon W. Ruttan
John F. Timmons

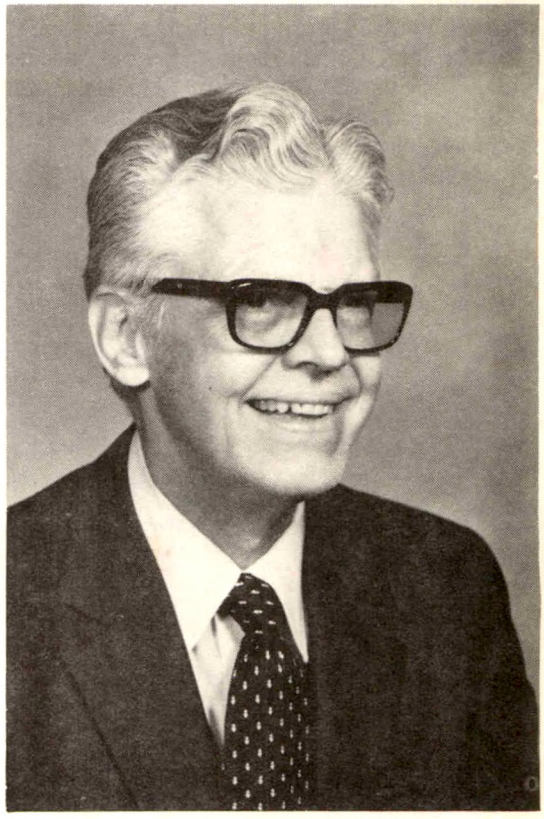
1975
Geoffrey S. Shepherd
S. V. Ciriacy-Wantrup
Holbrook Working

1976
Emery N. Castle
Arthur T. Mosher
Willard F. Mueller

1977
Lowell S. Hardin
Austin C. Hoffman
Sidney S. Hoos
Earl R. Swanson

Lowell S. Hardin

1977 Fellow



Professor, Department of Agricultural Economics, Purdue University, 1943–65; head of department, 1957–65.
Program advisor, program officer, Ford Foundation, 1965–present.
Consultant, Office of State Experiment Stations; member, Agricultural Board, National Academy of Sciences, 1966–72; member, Panel of President's Science Advisory Committee on World Food Supply, 1966–67.
Secretary-treasurer, American Farm Economics Association, 1953–57; vice-president, 1959; president, 1963–64.

Lowell S. Hardin has achieved an international reputation as a builder of professional talent and institutions. He has been a perceptive student of world agriculture, and he has contributed significantly to the joining of agricultural sciences with socioeconomic and policy concerns. Much of his influence is not copyrighted but reflected in the expressions, writings, and programs of others. He has given unselfishly of himself behind the scenes to nurture and encourage the professional growth of numerous students and colleagues. This style is characteristic of the best teachers and of the most self-effacing "developers of human capital."

Born in 1917 in Indiana, Hardin received his B.S. in agriculture from Purdue University in 1939 and his Ph.D. from Cornell University in 1943. He joined the Purdue staff in 1943 as an instructor and assistant director, National Work Simplification Project.

At Purdue University, Hardin had a distinguished career in teaching, research, and administration. He did pioneering research in work simplification and helped popularize techniques that in part contributed to today's operations research methodology. His book, *Farm Work Simplification,* is a landmark in the field.

Lowell Hardin was recognized as an excellent teacher by both his students and peers. He had a knack for bringing the practical into the classroom and, in the process, making important concepts come alive. Later, as an academic administrator, he led a development that saw traditional departments of agricultural economics transformed into departments that grappled with broad applications of economics to social and economic problems.

In 1965, Hardin joined the Ford Foundation. He was initially responsible for Foundation

agricultural programs in Latin America, but his responsibilities were later broadened through joint appointments to the Foundation's Office of the Vice-President (International Division) and the Office of the Middle East and Africa, with management project development, and monitoring responsibilities for several hundred projects around the world, and a significant share of the Foundation's budget for overseas operations. He has played a key role in the development of the international agricultural research centers and helped spearhead the creation of the Consultative Group for International Agricultural Research.

Hardin has been an intellectual leader, synthesizer and conceptualizer, "entrepreneur" innovator, and diplomat/statesman *par excellence*. He is specially noted for inviting the expression of contrary views and for absorbing and blending them into new ideas that push hard on the frontiers of conventional wisdom. In all of this, his wife, Mary, has been a constant partner. They have given unselfishly of themselves to help others realize their professional and personal potential.

Austin C. Hoffman

1977 Fellow



Vice-president, Kraft Foods, 1944–70; retired since 1970.
Director of Food Price Control, Office of Price Administration, 1941–43.
Economist, Division of Marketing Research, Bureau of Agricultural Economics, 1935–40.
Economist, Agricultural Adjustment Administration, 1934.
Assistant professor, University of Wisconsin, 1931–33.

Austin C. "Oscar" Hoffman is an agricultural economist who has blended with distinction careers in teaching, research, public service, and private agribusiness. While working with the late Frederick V. Waugh in the Bureau of Agricultural Economics, he was an innovating pioneer in the industrial organization approach to research in agricultural marketing. In the late 1930s, he contributed to marketing publications of that agency and of the Temporary National Economic Committee. His work on the economic principles of the Food Stamp Plan was original and anticipated later inquiry.

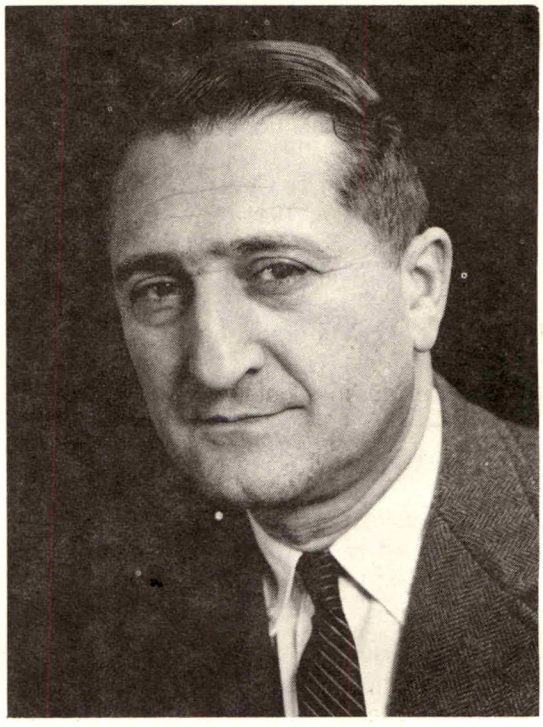
During World War II, Hoffman played the important role of directing control of food prices in the Office of Price Administration.

Beginning in 1944, he carved out a new career. As vice-president in charge of purchasing for Kraft Foods, he devoted his talents to management. He did not lose his scholarly research interests. He served frequently in liaison between business and academic economists. He took part in panel discussions, research symposia, and similar sessions. One of his published contributions was his penetrating analysis of the economics of conglomerate growth (1969). Since retirement he has continued to be professionally active. He has appeared before committees of the U.S. Congress to offer counsel on issues in industrial organization and antitrust policy. For years he has been a member of the Agricultural Committee of the National Planning Association.

It is a truism that most individuals are best able to perceive economic events when objectively detached from them. Rarely can an agricultural economist philosophize about the sector in which he is aggressively engaged. Not often can he see the broader public interest when daily concerned with the private interest. Hoffman has been simultaneously philosopher and practitioner in the marketing system for the products of agriculture. Our profession is the richer for his unusual capability.

Sidney S. Hoos

1977 Fellow



Professor, Department of Agricultural Economics, University of California, Berkeley.
Dean, academic personnel, University of California, Berkeley, 1964–67.
Consultant, Agricultural Settlement Department, Israel, 1960–61.
Chief economist and deputy chief, Requirements Branch Office of Quartermaster General, U.S. War Department, 1942–45.
Senior economist, assistant to president, Commodity Credit Corporation, Department of Agriculture, 1941–42.

Sidney S. Hoos grew up in Old Town, Maine. Mathematics and economics lured him from a career of teaching and playing the violin. He attended the University of Maine and the University of Michigan, where he received his B.S. in mathematics. The course of his life was changed by his decision to enroll in an economics course given by Visiting Professor Holbrook Working. He received his M.S. from the University of Michigan and then joined the Food Research Institute at Stanford, where he studied under Working. He earned his Ph.D. in economics in 1939 and accepted an appointment with the Giannini Foundation and the Department of Agricultural Economics, University of California, Berkeley.

Six months prior to World War II, Hoos went to Washington as an assistant to the president of the Commodity Credit Corporation. When the war started, he joined a small group in the War Department assigned the task of improving the methods used to determine material requirements for the Army. There he played a leading role in the development of the Army Supply Program, which was eventually adopted throughout the Army. He received a special commendation from the Commanding General for his work.

After the war, Hoos returned to Berkeley and resumed his career in undergraduate and graduate teaching, research, and public service. At an early age he was given full professorship in the Departments of Agricultural Economics, Economics, and Business Administration. Hoos had the reputation of being a dedicated and demanding teacher of students from all over the world.

Sidney Hoos worked closely with California agricultural industries in the application and implementation of research on their problems—research that he conducted with Harry R. Wellman and George M. Kuznets. His contributions to the agriculture of the state were recognized by numerous citations and

awards of merit. He also consulted with and advised state and federal government agencies and officials. His distinguished service to foreign governments earned him international stature and reputation. His long and varied bibliography includes articles in trade and professional journals, contributions to many books, and many reports.

Hoos's commitment to good citizenship has resulted in his serving and giving leadership to many significant committees and boards in the community and university. However, his heavy schedule in teaching, working with students, and in research continued unabated.

Throughout his career, Hoos has been an active member of our profession. He helped guide the Western Agricultural Economics Research Council through its formative years, and he served as president of the Western Agricultural Economics Association. He also served as vice-president of the American Agricultural Economics Association and made significant contributions on many AAEA committees.

Earl R. Swanson

1977 Fellow

Professor, Department of Agricultural Economics, University of Illinois, 1950–present; associate head, 1967–70; acting head, 1974–75.

Editor, *American Journal of Agricultural Economics,* 1965–68.

Member, Hazardous Materials Advisory Committee, U.S. Environmental Protection Agency, 1971–74.

Member, Corn/Soybean Study Team of the Study of Problems of Pest Control; A Technology Assessment, National Academy of Sciences, 1973–75.

Chairman, Selection Committee on Publications of Enduring Quality, American Agricultural Economics Association, 1974–75.

Cochairman, AAEA-ERS-SRS Committee on Agricultural Capacity, 1976–77.

Member, Research Advisory Committee, Agency for International Development, Department of State, 1976–77.

Ernest H. Wakefield Award, 1975, Agricultural Alumni Award of Merit, 1976, Paul A. Funk Award, 1977, University of Illinois.



Earl R. Swanson has been a leader in developing and applying the concepts of production economics and operations research to farm management, aggregate farm output analyses, the economics of soil and water conservation, and the impacts on farm output of public policy alternatives with respect to environmental quality.

Born in 1921 in Illinois, Swanson received his B.S., with highest honors, from the University of Illinois. He completed his M.S. at the University of Minnesota and his Ph.D. at Iowa State University. He also did postgraduate work at the University of Oslo, Norway. He joined the Department of Agricultural Economics, University of Illinois, in 1950.

Swanson has excelled in the depth of his analysis and in his ability to coordinate and lead research involving researchers from other disciplines. Publications by him attest to the care and creativity of his analysis and to his skill in communicating the results to others. He has made significant contributions to his department, college, and university and to numerous national and international committees concerned with public policy impacts on farm production. These contributions flow from the excellence of his research, his depth of knowledge, and the more subtle characteristic sometimes called wisdom and other times called good sense.

He has led in the development of operations research techniques for the analysis of farm management and aggregate farm production problems. He developed production models that incorporate dynamic features that take account of risk and the time horizon and integrate cropping and livestock systems that incorporate enterprise complementarities and

diminishing marginal returns. He analyzed difficulties involved in making the transfer of experimental results to actual farm operations and suggested methods for overcoming them.

Swanson has also provided empirical evidence that helps in understanding the differences and congruencies of private (farmer) and public interests in soil erosion control. Objective appraisal of public policy alternatives to take these differences into account has been a key feature of aggregate farm production analyses undertaken by him. His recent research activity has centered on decision processes related to environmental quality, technology assessment of weather modification, and measurement of agricultural production capacity.

He has been a visiting professor, Hokkaido University, Japan; Fulbright Research Scholar, Royal College of Agriculture, Denmark; visiting lecturer, USSR, under the US-USSR Cultural Exchange Program; consultant, Ford Foundation, India; research scholar, International Institute for Applied Systems Analysis, Austria; and visiting scholar, U.S. Environmental Protection Agency.

Throughout his career, Swanson has fostered and shared with his students and fellow workers an unusual skill to ask the right questions and to untangle the complex questions.

Presidents, 1910–78

1910–12
William J. Spillman

1913
George F. Warren

1914
Daniel H. Otis

1915
Andrew Boss

1916
Harcourt A. Morgan

1917
Henry W. Jeffers

1918
George A. Billings

1919
John R. Fain

1920
Henry C. Taylor

1921
Walter F. Handschin

1922
Benjamin H. Hibbard

1923
Thomas P. Cooper

1924
Edwin G. Nourse

1925
Milburn L. Wilson

1926
Thomas N. Carver

1927
John I. Falconer

1928
Lewis C. Gray

1929
H. E. Erdman

1930
Harold C. M. Case

1931
Oscar C. Stine

1932
John D. Black

1933
Howard R. Tolley

1934
William I. Meyers

1935
Waldo E. Grimes

1936
Joseph S. Davis

1937
Oscar B. Jesness

1938
Ernest C. Young

1939
Irving G. Davis
Foster F. Elliott

1940
Hugh B. Price

1941
Murray R. Benedict

1942
George S. Wehrwein

1943
Sherman E. Johnson

1944
Eric Englund

1945
Lawrence J. Norton

1946
Frederick V. Waugh

1947
Asher Hobson

1948
William G. Murray

1949
Oris V. Wells

1950
Warren C. Waite

1951
Forrest F. Hill

1952
George H. Aull

1953
Harry R. Wellman

1954
Thomas K. Cowden

1955
Joseph Ackerman

1956
Karl Brandt

1957
H. Brooks James

1958
Harry C. Trelogan

1959
Raymond G. Bressler, Jr.

1960
Willard W. Cochrane

1961
William H. Nicholls

1962
Bushrod W. Allin

1963
George E. Brandow

1964
Lowell S. Hardin

1965
D. Gale Johnson

1966
Kenneth L. Bachman

1967
Lawrence W. Witt

1968
C. E. Bishop

1969
Harold F. Breimyer

1970
Dale E. Hathaway

1971
Jimmye S. Hillman

1972
Vernon W. Ruttan

1973
Emery N. Castle

1974
Kenneth R. Tefertiller

1975
James Nielson

1976
James T. Bonnen

1977
Kenneth R. Farrell

1978
R. J. Hildreth

R. J. Hildreth

1977–78 President



Managing director, Farm Foundation.
Secretary-treasurer, International Association of Agricultural Economists, 1973–present.
Member, American Agricultural Economics Association; Agricultural Economics Society, England; Western Agricultural Economics Association; American Economics Association; Southern Agricultural Economics Association; Canadian Agricultural Economics Association; Phi Kappa Phi; Sigma Xi.

R. J. Hildreth is managing director of the Farm Foundation, Oak Brook, Illinois, a position he has held since 1970. Prior to that time he served as associate managing director of the Foundation.

Hildreth was raised on a farm in central Iowa. He did his undergraduate work in industrial economics at Iowa State University, where he specialized in labor economics for his M.S. The following two years he taught at Augsburg College, a small liberal arts college in Minneapolis, Minnesota. After receiving his Ph.D. from Iowa State University in 1954, he spent four years teaching and researching farm management and production economics in the Department of Agricultural Economics, Texas A&M University. He became research coordinator for West Texas in 1958 and assistant director of the Texas Agricultural Experiment Station shortly thereafter. In this position he was responsible for research project development.

He has written broadly in the field of agricultural economics. His writings include journal articles and experiment station publications; he has contributed chapters to a number of books, edited a book of readings in agricultural policy, and coedited a book on research methods in resource economics.

Hildreth has long been active in the AAEA. He has served on the Board of Directors and as chairman of the Visiting Lecturer Committee, the Professional Activities Committee, and the Economic Statistics Committee.

The American Agricultural Economics Association: Its Prospects

R. J. Hildreth

The American Agricultural Economics Association (AAEA) is at a significant juncture. Breimyer, in his 1968 presidential address, said, "the . . . Association (will) want to give thoughtful attention to how it can best conduct its internal affairs in the years to come" (p. 1111). Almost a decade later, few people inside or outside the Association appreciate the significance that should be attached to the direction we take.

Many Association members have a hard time seeing the linkage between activities of the Association and the contribution our profession can and should make to the well-being of people in society. Many members expect the officers to keep the Association providing the services they desire at a reasonable cost and do not wish to spend too much time on its affairs. A successful Association requires active support and participation from its members.

If I were to propose to terminate the Association, concern would be expressed by a large number of members. Such a proposal would likely lead to considerable excitement and perhaps some useful discussions. I do not choose to put forth such a proposal but rather to discuss less drastic alternatives. I hope in this process to stimulate useful discussion to improve the workings of the Association.

My discussion starts with an examination of the relationship of the Association and its members, then the relationship of the Association and society. Some opportunities for the Association are presented, and two strategies for the Association are developed.

Presidential address.

R. J. Hildreth is the managing director, Farm Foundation.

The author is indebted to the agricultural economics faculties at Cornell University, University of Illinois, Oklahoma State University, Pennsylvania State University, Purdue University, Washington State University, University of Wisconsin, as well as the Economic Research Service, U.S. Department of Agriculture staff, where he presented seminars on the topic. He also profited from reviews of early versions of the paper from the officers and directors of the AAEA, members of the Professional Activities Committee, and other colleagues. Appreciation is expressed to Madelyn Naumes for hard work and care in preparation of the drafts of this paper. However, they are in no way responsible for the contents.

The AAEA and Its Members

The changing nature and structure of the profession was described by Bonnen in his "Report of the President." He said, "Twenty years ago, to be an agricultural economist was automatically to be a member of the AAEA. That was the way in which one identified oneself; it was universally expected" (p. 1033). Today, the situation is different.

A characteristic of professional groups is that they "profess" something. The "profession" of agricultural economics groups has moved from a few concerns to many and diverse concerns. The diversity of the membership of the profession and the Association has increased. There has been increasing specialization among agricultural economists. Agricultural economists are fragmented into many, far narrower, specialties than in the past. Regional interests have led to the growth of regional associations in the South, the West, and the Northeast. Members have interests in research, teaching and extension, and administration. Some members work for universities, for the government, for private firms, or even for thenselves. Most academicians work for land-grant universities, while others work for state universities or community colleges.

Johnson's paper, given at the recent International Conference of Agricultural Economists, usefully illustrates the diversity. He discusses the contribution of agricultural economists in roles as participants in decision making, as doers of subject matter analysis, and as doers of disciplinary analysis. He suggests all three roles are important, and none should be denigrated. Participants in decision making focus on a specific particular problem, and the economic analyst in this process "contributes theory, empirical knowledge, and command over quantitative techniques for handling empirical information and for processing it into prescriptions" (pp. 29–30). Subject matter analysis is designed to bring to-

gether information on a specific subject that would be relevant for solving a set of problems requiring that kind of information. Johnson defines economic disciplinary analysis as "attempts to improve theories, quantitative techniques and data of economics" (p. 34).

Agricultural economists participate in one or more of these roles. Thus, I prefer to use the word "profession," as opposed to "discipline," when speaking about the full range of activities of people who were trained as agricultural economists and call themselves agricultural economists.

These trends and issues are not unique to the United States. Kenneth Hunt of Oxford University, reviewing agricultural economics in Great Britain since the 1920s, observes the principal aim in the 1920s and early 1930s was supplying farmers' needs for management advice. He offers among his conclusions the following: "Increased professionalism, besides giving much greater operational skills to decision makers, has (i) encouraged segmentation of the subject as it stood, (ii) created an interest in the academic aspects as such—in the pursuit of knowledge and not in application. . . . These tendencies have led to the formation of various specialists' societies and journals (e.g. in connection with labour, farm management, rural sociology, administration, history, food policy) developments which seem to have been viewed with fairly unalloyed approval as a contribution to high professional standards" (p. 293). Hunt concludes that these and other developments have resulted "in British agricultural economists being unsure of the proper boundaries of their work—either subjectwise (e.g. toward politics) or in the field (e.g. toward food industries)" (p. 293).

The "concerns" (both meanings: a business and solicitous regard) of agricultural economists have become broader and more diverse (Hunt). Most members still acknowledge being agricultural economists but add an individual, specialized identification. The glue that held the profession together has become less sticky.

Benefits and Costs of AAEA Membership

At the same time that the diversity within the profession has increased, the services provided by the AAEA have remained quite general and collective in nature; that is, most of its services are available to members and nonmembers alike. Thus, it has become difficult for many members of the profession to identify closely with the Association. It is not surprising that most individuals question the value of being a paying member, since as nonmembers they can gain most of the benefits.

What are the benefits and costs of Association membership to individual agricultural economists? The costs are relatively easy to determine. They mainly consist of dues of $25 per year for regular members.

There are certain costs for those who become active in the Association as officers and committee members. However, these latter costs need not concern us a great deal, as the individuals would not become active in the Association unless the benefits, however measured, were greater than the cost to themselves.

The benefits from the Association vary from individual to individual. When the question is raised as to the benefits of joining the Association, the response that comes forth early in the conversation is the *American Journal of Agricultural Economics*. What benefits does the *Journal* provide the members of the Association? It is a source of new ideas in the field of agricultural economics. The *Journal* provides an opportunity to publish and so have one's ideas subject to peer review. An article in the *Journal* is an important factor in promotion and tenure for university economists. Another benefit from having an article in the *Journal* is an increase in self-esteem above the tangible promotion and tenure benefits. The *Journal* can also be put on the shelf for later reference; it also may be put on the shelf for the status it gives by having it on the shelf for others to see.

The benefits from participation in annual meetings are often mentioned in discussing the Association. The benefits are diverse and often subtle. The annual meeting is a very large information exchange with the content ranging from highly technical to rumors. The annual meeting provides a chance to see your classmates from graduate school and also their families—as long as the Association meets on campuses with low-cost facilities. The annual meeting provides a meeting time and place for technical committees as well as committees planning other activities in the profession.

A major service of the annual meeting is related to the role of the Employment Committee. One of the benefits of Association

membership is the market for jobs it provides at the annual meeting, and during the year through the efforts of this committee and the employment registry. This service is of considerable importance to graduate students, members of the Association who wish to change jobs, and employers desiring to hire agricultural economists. If the Association were disbanded, the function of recruitment and job hunting probably would be quickly institutionalized in some other form.

The services provided by the *American Bibliography of Agricultural Economics* is directly useful to some members. The small subscription list when it was published in hard copy is evidence that the number is limited. Since the *Bibliography* has been "on line" only a short time, it is difficult to determine how much use has been made of it. Approximately thirty departments of agricultural economics have access to the information through their university library terminals. It has a large potential for the profession as well as individual members.

A very real benefit to the individual member is contained in the belief that the Association contributes to the general good of the United States and world society. Many individuals may receive few tangible benefits from their membership in the Association, but they are convinced that the growth and development of the profession is important to society, and they wish to have a part in supporting that kind of contribution to society.

In summary, it may be helpful to think of AAEA as a system of five services to its members: *(a)* information services such as literature retrieval, search and documentation center, and news notes; *(b)* educational services like papers at annual meetings, *Journal* articles, seminars and conferences, and book reviews; *(c)* legitimating services like publication in *Journal,* awards program, and use of Association credentials; *(d)* employment services such as the registry and job market at annual meetings; and *(e)* fraternal services like social events (formal and informal) at annual meetings, some aspects of awards program. The system is not completely specified. Some items, such as the *Journal,* have a long history; others, such as the employment registry, are developing.

How could the Association improve its services to members? Examples include increasing the coverage and use of the services of bibliographic search and documentation center, especially international literature, and publishing more abstracts in the *Journal* (informational services); developing alternative subject matter publications of interest to specialized subject matter groups and holding seminars and workshops for specialized subject matter groups (educational services); developing a program to certify agricultural economists and accredit departments of agricultural economics, and increasing the opportunity to publish *Journal* papers by an alternative publication or expansion of the *Journal* (legitimating services); developing a year-round job market, in addition to the registry and annual meeting job market (employment services); and offering insurance to members, providing tour and travel services (fraternal services).

Another set of issues deals with the roles of agricultural economists discussed earlier. How can the Association better serve agricultural economists in the roles of participant in decision making, doers of subject matter analysis, and doers of disciplinary analysis? How can the Association promote and develop the better use of economic theory and contribute to theory development? How can the Association assist the very specialized subject matter analysts who are members of the Association to gain knowledge and insight from theory as well as the experience of participants in decision making? How can the Association improve the distribution of the results of subject matter analysis and disciplinary analysis?

The present and possible set of services are broad and diverse. In addition to the level of services provided, questions of the mix of services exist. Decisions about the level and mix of services are related to resources available to the Association.

Public Good Aspects of AAEA Services

Many of the services of the Association have public good aspects for members of the profession. The usual characterization of a pure public good includes indivisibilities in production, as well as jointness of supply and inefficiency of excluding others from its consumption, once it has been supplied to some members of the community (Mueller). It is difficult to exclude nonmembers from the user benefits of the *Journal,* the annual meeting, the registry, and the general society good produced by the Association. It would also be difficult for an individual member, depart-

ment, or organization to produce these goods. While Association services are not pure public goods, they are close enough for public goods analysis to be useful.

The property of difficulty of exclusion raises the probability that purely voluntary methods for provision of the public good will break down because of freeloading. As the size and heterogeneity of the community of potential users increases, freeloading increases. Faced with some deterioration in the financial state of the Association and increased awareness of this logic, the Board in 1976 adopted the following policies governing services: *(a)* the AAEA should, in general, limit committee membership to AAEA members; *(b)* higher registration fees are to be charged nonmembers registering to attend the annual meeting; and *(c)* the privilege of presenting contributed papers, as well as presenting and discussing invited papers at the annual meetings, should be limited to AAEA members, except in special cases in which the condition is waived by the president. These moves, as well as other items under study, would make a careful and thoughtful transformation of what have been collective goods available to all into selective goods available only to members or at preferential rates to members.

Publication in the *Journal* has private good aspects for the author's organization. The decision in 1975 to institute page charges is a recognition of this fact, as well as the need for income.

The literature dealing with public choice also discusses quasi-public goods. Pure public goods require some voting process for revealing preferences. For private goods, the entry and exit of buyers and sellers perform the same function. However, quasi-public goods require a mixture of entry, exit, and voting processes.

Two methods that have been suggested for dealing with quasi-public goods are "voting with the feet" and "theory of clubs." The voting-with-the-feet process is useful when the assumption of joint supply is dropped. The preference for the quasi-public goods is revealed through the silent voting with the feet of individuals exiting and entering communities producing the various combinations of quasi-public goods. Voting with the feet groups individuals together in communities of homogeneous tastes.

The theory of clubs operates when exclusion is possible and the addition of a member lowers the average cost of a good. A club of people with homogeneous preferences is formed to take advantage of economies of scale. In regard to clubs, Mueller concludes, "The voluntary formation of clubs to allocate public goods is efficient only when the optimal club size is relatively small, i.e., when the quasi-public goods have a limited degree of publicness" (p. 413).

Thus, both methods result in a group with homogeneous preferences producing a quasi-public good. The growth of new journals in areas of consumer affairs, recreation, natural resources, operations research, etc., may well be examples of these ideas. The formation of regional associations is also a weak example. It would be possible for the Association to adopt a structure that would foster within the Association small groups with homogeneous preferences, such as farm management extension economists, undergraduate teachers, etc. Such a course of action would create a snug harbor for the diverse interests with opportunities for venturing out to the larger sea of agricultural economics.

Financial Resources

Present and potential services to society and members are constrained by financial resources. The AAEA, while a not-for-profit organization, is clearly a not-for-loss one. It is instructive to examine membership and financial data of the Association for recent years. The total number of members and subscribers reached a high point in 1975 (5,966) after a low point in 1973 (5,478) and some recovery in 1974 (5,775) (Redman). As will be reported, the total in 1976 was 5,841. The dip in membership in 1973 was caused by a substantial decline in regular members. Regular members increased from 3,282 in 1975 to 3,497 in 1976; the year dues increased from $15 to $25. Foreign members and subscriptions have remained a fairly constant percentage of total members and subscriptions: about 33%.

The issue of market penetration, the number of potential members compared with membership in the Association, is often raised. In 1975 the Membership Committee concluded that only one-half of all U.S. agricultural economists are members of the Association. Further analysis will be forthcoming from the Membership Committee.

Turning to the financial affairs of the Association, the balance of income and expenses

was negative in 1974 and 1975 (Redman). The balance for 1976 was positive; we are back in the black. Income rose in 1973, 1974, and 1975, but costs rose faster during this period. Since the books are kept on a cash basis, the numbers for one year do not necessarily reflect the income and expense of that year's activity. An accrual accounting system would give more information.

The structure of costs of the Association is similar to that of a motel or hospital. Practically all of the costs are fixed within a one-year period. A decrease or increase in membership of 500 to 1,000 would have little effect on the expenses of the Association. The only variables would be postage and paper for the *Journal* and the secretary-treasurer's office expense. All other costs remain relatively fixed. Thus, increases or decreases in membership have great effect on the financial position of the Association.

There is a reasonable probability that the Association can equate income and expenses over the next few years with present activities. *Journal* costs probably will not increase as rapidly as in the past. Expanded membership would assist the income side. The Association will have to manage carefully to equate income and expenses, but it likely will be achieved.

The AAEA and Society

U.S. society sanctions the AAEA by providing special status to it as a nonprofit organization. In beginning a discussion of the Association and society, it may be useful to ask why this is so. The answer appears to be found in society's views toward professional associations, not just our Association. Through its various and diverse decision units, society acts as though development of knowledge in a professional field is a good thing. The Constitution of the AAEA recognizes this point of view. Article II states: "The object of the Association is to further development of systematic knowledge of agricultural economics" (*Handbook-Directory*, p. 10).

Just as the membership of the Association is heterogeneous, so is U.S. society. It is made up of many publics that have an interest in agricultural economics knowledge. Listed among these publics would be consumers, farmers, firms selling to and buying from farmers, food processing and distribution firms, managers of natural resources, community and local government officials, students, professionals in related social science and agricultural fields, and universities. Each group views the Association and the related profession of agricultural economics from a slightly different perspective. However, it is likely that the various publics see the affairs of the Association as a means, not an end.

The systematic knowledge developed as a result of Association activities enables society to understand and predict phenomena in agricultural economics as well as develop and evaluate alternative courses of action for decision. The AAEA is a means for the improvement and development of agricultural economics knowledge, which, in turn, is a means of dealing with the many and varied problems faced by the society and its parts.

The Value of Agricultural Economics Knowledge

The increased demand for agricultural economics (and other social sciences) knowledge by a society facing a larger number of interdependent problems is one of the major foci of relations among society, the profession, and the Association. In thinking through the relationship between the Association and society, some concept of what the publics desire from agricultural economics knowledge is helpful. Ruttan holds that the demand for knowledge in the social sciences comes from a concern for the efficient performance of institutions. He states: "Advances in knowledge in the social sciences can lead to more efficient performance of existing institutions and to the innovations leading to the development of new and more effective institutions" (p. 4). Among the examples he gives are quantification of commodity supply and demand relationships, which leads to more effective functions of food procurement and distribution programs (either by private firm or public organization), and knowledge of the effects of land tenure or group farming arrangements, which might lead to institutional innovations, in turn causing more equality in access to resources and thus increased productivity.

Many of the future problems of the Association and the profession may well be due to certain elements of society placing a high value on our past performance. To the degree that they continue to value the present activities highly, the demand on the profession

will continue to increase as problems become more complex and numerous.

Legitimacy of Agricultural Economics and the AAEA

Legitimacy is related to the value placed by the units of society on agricultural economics knowledge. The profession of agricultural economics and the Association are given legitimacy or status by its publics.

Legitimacy is a rather sensitive subject. Without legitimacy, neither the profession nor the Association could sustain themselves in a social system. Should the various publics deny legitimacy, the profession and the Association would be unable to keep themselves alive. No individual or group can continue to perform a role unless that role is accepted by those who are affected.

Boulding, in discussing the legitimacy of central banks, distinguishes at least six legitimating elements for an organization: payoff, willingness to make sacrifices, age, mystery, ritual or artificial order, and alliances with other legitimacies.

The units of society granting legitimacy appear to value payoff highly; that is, they all accord more legitimacy to the profession of agricultural economics and the Association to the degree that it produces and delivers knowledge that leads to more effective performance of existing institutions and innovations in institutions. The point to be made is that the Association is granted legitimacy by many of the units of society, in large measure, to the degree that it furthers the "development of systematic knowledge of agricultural economics."

How the AAEA Serves Society

There are two major routes through which the Association can serve society. The first is the provision of a set of services for its members and the agricultural economics profession. The services will enable the individual members of the profession to provide information for improved performance of economic institutions and better use of resources. The second major route is for the Association to provide this information directly to the various elements of society. Although the development of normative policy statements by the Association is prohibited by the AAEA Constitution in article II, the Association can provide economic information on policy alternatives and consequences as well as other economic information that would improve the performance of institutions in society. Farrell suggested this kind of activity in last year's presidential address.

The Association does little to deal directly with the various units of society. Should the Association expend more effort to produce and distribute knowledge directly to the various publics, or should it continue to work mainly through its members to improve the production and distribution of knowledge? Among the ways the Association could produce and distribute knowledge to society would be *(a)* to join the Council on Agricultural Science and Technology (CAST) or develop the means itself to make statements as does CAST; *(b)* to provide accreditation services for undergraduate and graduate curricula; *(c)* to change the *Journal* into more of a communications device for users of agricultural economics research; *(d)* to devise an alternative publication aimed at users of agricultural economics knowledge (an example might be *Crops and Soils,* published by the American Society of Agronomy); *(e)* to devise sessions at the annual meeting for the interested publics; *(f)* to hold special symposia for consumer groups, legislators, firm managers, students, farmers, etc.; *(g)* to develop statements of needed agricultural economics research for use by agricultural research planning and funding organizations; and *(h)* to make special efforts to communicate with general publics. Analysis and debate of costs and benefits to society and the Association on each item would be required before action could be taken.

If the Association were to order its services with the goals of improving the performance of the profession from the point of view of certain publics, priorities could well change. To achieve this ordering, a good deal of thought and discussion would be required. For example, what mix of services would improve the ability of economists to do research, teaching, and extension work useful to society? How could the Association provide incentives for agricultural economists to communicate more clearly and usefully the results of their analyses? Should the Association direct its efforts toward an elite group of the best agricultural economists or should more effort be put to improve productivity of all agricultural economists?

It is easily conceived that the Association could and should challenge agricultural economists. An example is the statement of T. W. Schultz, in his Leonard Elmhirst Memorial Lecture, that there is increasing opposition to economics in social and political thought as well as debasement of economics by government. Schultz charges that there is an unwillingness and inability on the part of economists to challenge this adverse drift. He points out that the opposition to economists is not restricted to a particular kind of government, or officials from high- and low-income countries. He states: "The hard realities of the cost of producing goods and services are not abolished by either national or international politics. Herein lies not only the hope, but the necessity of economics" (p. 4).

Many difficult and emotional issues lie in these thickets. I do not have easy solutions to them. But the issues need to be faced if the Association is to better serve society.

Some Opportunities

I now discuss some persistent issues and opportunities that appear to transcend the specific suggestions made earlier. I do not present a detailed plan for the future of the Association. Its future will be determined by the action of the Board and the membership. Significant steps have been taken recently to exploit opportunities for the Association. Examples include appointment of new committees to study and make recommendations about alternative publications, business organization and management of the Association, evaluation of the annual meeting, and professional registries. The reinstitution of the Professional Activities Committee also serves to bring useful examination to a number of issues. The actions coming from the reports of these committees will serve the Association well. However, unless the membership cares about the Association and actively supports improvement, little change will occur.

The Journal

Controversy continues to swirl around the *Journal*. In the early years of the profession, the *Journal* was virtually the only medium available for published communication among agricultural economists. Now other publications exist but interest in the *Journal* remains high, as it is a very visible activity.

W. G. Tomek, present editor, in an interesting piece titled "Is There a Disequilibrium Between Supply and Demand for Articles in the Journals of Agricultural Economics?" lists the following complaints of readers: "articles are too mathematical; topics covered by the *Journal* are not sufficiently diverse; the topics covered are too narrow and specific; i.e., the big issues are not discussed; articles tend to be methodological in emphasis rather than concentrating on policy issues; too much emphasis is placed on articles derived from theses, and this conveys an image of a necessary methodological content for publication, and this in turn discourages ideas or issue-oriented manuscripts; readers also want articles reflecting the judgment of mature members of the profession on policy questions; articles allegedly do not cover topics of interest to extension economists, undergraduate teachers and business economists; and readers see a need for more literature review articles" (pp. 1–2).

Tomek points out that not all the papers are methodological or mathematical; e.g., the 1975 *Journal* published 147 pieces of which 20 emphasized methodology. He concludes "The problem is the lack of enough high quality, important things to publish" (p. 8).

There appears to be disequilibrium between supply and demand. Why? The *Journal* articles published are a selection from the manuscripts submitted. Apparently, not sufficient "high quality, important things to publish," as viewed by the readers, have been submitted. I reject the position that the editors have a bias against "high quality, important things." Why are such manuscripts not submitted? Two possible reasons occur to me. One, agricultural economists are not doing high quality, important analysis. Two, if they are doing such analysis, they are not submitting the manuscripts to the *Journal* for publication. Both are possible, but I tend to accept the second reason as more important. If I am correct, commissioning of articles by the editor, alternative publications, and the creation of an environment that will bring submission of important and high quality manuscripts are in order. Thought, concern, and work by the editor, Alternative Publications Committee, Executive Board, as well as members will be required to make improvements on this complex issue.

Involvement of Members

Many members view themselves as second class citizens in the Association. The expressions of concern, sometimes near violence, varies over time. I have heard such views from agricultural economists in the South, Northeast, West, and North Central regions. I have heard complaints from teachers, extension workers, and people employed in industry. Members from non-land-grant and small land-grant universities have voiced concern.

Two avenues exist to deal with this issue. One is for the president and Executive Board to continue to improve opportunities for an "open," as opposed to "closed," style in the affairs of the Association, e.g., committee appointments, annual program, etc. The second is for the members who feel anguish to become usefully assertive. Sending suggestions to the president and the Board and volunteering for activities and developing feasible alternatives would help. Both avenues need to be traveled.

Membership

The ability of the Association to provide improved services to society and its members is constrained by its income. The nature of costs discussed earlier, as well as need for new income for new services, makes an increase in membership a high priority item. The recently increased efforts of the Membership Committee and the secretary-treasurer need to be continued. Often failure to join or renew membership is an act of omission rather than commission, so presenting multiple opportunities, i.e., "hitting them often," will yield results.

But the members also have an opportunity and responsibility. Personal contact is probably the most effective of all sales techniques. It appears logical that, if you think membership is worthwhile, you should attempt to persuade others to belong to the Association.

Two Strategies

I have difficulty in defining clear-cut alternatives for decisions about the future of the Association. The affairs of the Association are complex and subtle. Two major strategies can be identified. One is to determine what the central core of the profession of agricultural economics should be and to meet the needs of society and members having preference for working in this central core. The second strategy is to recognize and foster the diversity and lack of homogeneity. This strategy would have the Association become a "federation" or a holding company of "clubs" or interest groups.

Among the consequences of the first strategy is the necessity to determine the central core of agricultural economics. A similar issue was debated early in the 1900s. Taylor and Taylor, in the *Story of Agricultural Economics*, report the cleavage between rural economics and farm management. The Committee on Instruction in Agriculture, chaired by T. F. Hunt, recommended in 1911 the use of the term "*rural economics* as applicable to the general field of economics in its relation to agriculture and rural communities" (p. 95). The acceptance of this report by administrators in colleges of agriculture and the USDA led to the formation of departments of rural or agricultural economics and the consolidation of the American Farm Management Association and the Association of Agricultural Economists under the title of American Farm Economic Association in 1919. The debate on the central core continues. A number of departments have changed or added to the name of agricultural economics and proposals are often made to change the name of the Association.

Whatever the definition of the central core of agricultural economics, it is likely a definition would lead to a reduced number of members. The Association would probably continue to operate as in the past, with one *Journal*, an annual meeting, and other services. Some attention would have to be given to styles of decision making and involvement of members, but with agreement on and commitment to the central focus, these problems become less intense. A major uncertainty is obtaining a definition of agricultural economics to which a sufficient number of agricultural economists would be committed to continue as an Association.

The question: "Can diversity become strength?" is crucial for the second strategy. The arguments for diversity that apply to firms do not apply well to organizations that produce public goods for their members and attempt to serve society. Arguments for diversity in markets and private goods production relate to serving the various interests of users or the buyers. Even here, unless there is some common bond, the market or organization dis-

solves. What is the "tie that binds" professionals with diverse concerns who produce and distribute agricultural economics knowledge?

I hold that there is a bond consisting of three elements. The first element is the set of interrelated problems analyzed. The problems focus on the food system as well as rural communities and resources. The problems were more closely related in the past. Most of the activities of the food system took place in rural communities and used rural resources. Now the activities of the food system involve urban people and resources and have an international dimension. Even though the relationships of the food system and rural resources are not as tight as in the past, rural areas are indispensable. The second element is the relationship to economic logic. Agricultural economics analysis often draws from other disciplines but almost always draws from economics. The third element is an empirical emphasis. Throughout the history of agricultural economics, conclusions have been expressed largely in numbers as opposed to conclusions based on logic only.

It appears to me the diversity and specialization in the profession can be placed under these elements and the elements serve to differentiate the profession of agricultural economics from other professions. The users of knowledge produced and distributed by agricultural economists will benefit from intellectual interaction and even friction among members with various concerns. The member who is in a decision-making role will better serve his organization and society by discussion and argument with the subject matter analyst and the discipline analyst. The subject matter analyst will do better analysis from interaction with decision makers and discipline analysts. So also will the output of the disciplinary analyst be more useful as a result of interaction with the decision maker and the subject matter analyst.

Concluding Comments

There is a common thread in the fabric of this discussion that may not be as apparent as it should be. The Constitution states the goal of the Association is furthering the development of agricultural economics knowledge. This statement implies the development of high quality agricultural economics knowledge. Excellence is important. Both society and members will be served to the degree that the Association stimulates, fosters, and indeed demands excellence. The different users of agricultural economics knowledge have varying perceptions of excellence. This suggests two major tasks for the future. One is helping user publics develop high standards of excellence concerning agricultural economics knowledge. Another is to raise all members' appreciation of excellent performance in teaching, research, extension, and decision making.

Let us join in assaulting the barriers to excellence in the development of agricultural economics knowledge.

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Natural Resource Economics: The Upsetting Discipline

M. M. Kelso

Robert Solow, in his 1974 Richard T. Ely lecture, remarked that "it is easy to choose a subject for a distinguished lecture like this, before a large and critical audience with a wide range of interests. . . . It has to be, because twelve people, counting me, have done it" (p. 1). Much the same thing can be said about this, our annual "distinguished" lecture, though but ten, including me, have done it. Of course, what really makes it easy is that the president calls you on the phone and says, after the usual introductory niceties, "Hey! How about you doing the fellow's lecture this year?" After a certain amount of hemming and hawing and sparring around, you say, "What do you want me to talk about?" to which he replies instantly, "That's entirely up to you! That's *one* thing I don't have to worry about in putting this bloody program together!" So there you are. It is easy!

My discussion will be more a personal testimony than an intellectual performance. I trust, of course, that my testimony will contain intellectual nourishment. It would be out of place before an august assembly of intellectuals like this if it did not. But its intellectuality may be somewhat hidden because it will not be couched in intellectually brilliant analytics nor in soaring conceptual hyperbole. But I take comfort in Adam Smith's oft-quoted remark about the "invisible hand" and hope that the intellectuality in my personal testimony may lead you, as by an invisible hand, to new insights into your unconscious biases, hence recognition of what may be restraining unconscious assumptions in your conceptions of society and the world. I hope the result may be that you will then play leading roles in what I shall argue are imperative changes in our economic view of man and his world if we are to help our society to avoid the apocalypse.

Fellow's lecture.

M. M. Kelso is a professor emeritus in the Department of Agricultural Economics, University of Arizona.

Intellectual Background

Some forty-five to fifty years ago I came into what then was called land economics almost coincidentally, quite, even, by accident. I see myself as then, a naive, idealistic, intellectual youngster who had just received his B.S. degree in agriculture, with a major in animal husbandry, from the University of Minnesota and who had accepted a research assistantship in agricultural economics at what was then Connecticut Agricultural College (now the University of Connecticut). I was to assist in economic research in land utilization on dairy farms in the eastern highlands of Connecticut. That experience whetted my interest in, and appetite for, study of the economics of land utilization in agriculture. The University of Wisconsin was at that time preeminent in its offerings in land economics, so I went there in 1930 to pursue graduate work leading to the Ph.D. degree in agricultural economics with a dissertation topic in land economics, minors in sociology and constitutional law, and with a sizable dose of institutional economics administered by John R. Commons, then approaching the end of his illustrious career.

From the vantage point of maturity and experience, I look back on those college years and the twenty years of professional work in land economics in the New Deal's Resettlement Administration, in the Division of Land Economics of the "old" Bureau of Agricultural Economics in the U.S. Department of Agriculture, and at Montana State College with a profound sympathy for what was then a nagging worry, sometimes conscious, more often subconscious, but always with me, a worry that concerned the conceptual and analytical relations between land economics and the accepted body and conventional wisdom of the rest of agricultural economics and its parent economic theory.

My naive idealism, born of the conventional wisdom and accepted economic dogma of the

times, assumed intellectually that maximized aggregate welfare would flow from maximized individual welfare were it not for the aberrations of monopoly and monopolistic elements in the economy, the humanness of the all-too-human actors in the drama, public interference in the market system, and the like. I know now that my association with those great iconoclasts, Veblen and Commons, and my experiences in the droughts and great depression of the 1930s generated within me gut feelings of skepticism regarding that intellectual idealism. It was, I can testify, a period of intellectual and philosophical discomfort for me. But I was not aware quite why.

I know now I was trying to accommodate my conceptions of land economics (we now call it the economics of natural resources) to the accepted body of conventional wisdom of agricultural economics and economic theory. But I could not bring it off—not that I tried very hard. It was sort of like a chronic nagging discomfort lived with so long and so intractably that one sort of accepted the notion unconsciously, even rationalistically, that it is the natural state of things, common to all persons similarly situated, part of the inevitable burden of living—and intellectualizing.

I came closest to resolving the paradox or, maybe more accurately, came closest to grasping the sources of the paradox through my intellectual association with the Wisconsin institutionalists, notably John R., as we students affectionately called him, and from my New Deal experiences during the depression that, in fact, were but the application in practice of much of John R.'s intellectual insights, though most of us, including me, did not then quite realize it!

I well remember my first intellectual insight that brought land economics and conventional agricultural economics together in one very small way. It was soon after I went to Montana State College in 1946 as an agricultural economist specializing in ranch and public land management. That was a time of ferment among western federal public land ranchers over their relations to the public lands, to the federal bureaucracy, and to federal land managers. I had been working with a Committee of the American National Cattlemen's Association on the question posed naively and dichotomously by it as to whether the public grazing lands should be privately or publicly owned, the Committee biased in favor of the former because its members were "fed up" with the difficulties and frustrations of the latter. I, like the Committee, had been viewing the problem dichotomously as one or the other. I was trying to think my way through the issue in order to find some way to resolve the conflict. Emotionally, I could accept the graziers' frustrations but intellectually I could not accept the dichotomous solution of universal private ownership of all the then public grazing lands.

One day (it would have been in 1946 or 1947) I was driving from Bozeman to eastern Montana on some mission I do not now recall. As most of you know, distances in Montana are vast; traffic in those days was light. So to relieve the boredom of uneventful hours behind the wheel, I let my mind mull over the public land problem that was so much in my thoughts. It came to me suddenly as an intellectual insight so clear that I could without much trouble, if only I were of a religious turn of mind, have attributed to divine inspiration, that what we were dealing with here was a problem of landlord-tenant relationships on the public lands versus private ownership of those lands, that the solution was not an either/or choice between what we had and something totally different but between what we had and a reformed system of public landlord-private tenant relationships and between that and private ownership, and, further, that because it would be impossible to persuade the public to divest itself totally of ownership rights in much, even most, of the public grazing lands, the solution for the private grazier users was to recognize and accept their status as tenants on much of the public lands and to work for improved landlord-tenant relations between themselves and the public landlord. Immediately all I had learned in land economics about improved landlord-tenant relations in agriculture came to bear, and I began to click-off mentally a multitude of logical and feasible changes that would give tenant graziers security of expectations with compensation for disturbance and improvements and that would protect the public landlord in the conservation of his land holdings.

I regret to say that nothing came of all this except my own intellectual growth. But even that growth, such as it was, still left me with my feeling of inadequate conceptual merging of land economics and conventional agricultural economics. I found my land economics useful in conceptualizing the role of the government as landlord and of the rancher as ten-

ant and the nature of the rights, duties, liberties, and exposures that characterized their relationships as well as possible changes in those institutionalized relationships that would presumably improve efficiency and equity for both. But, whereas I was correctly conceptualizing the rancher as a private individualized firm as required by conventional economic theory, I was, for purposes of the same theory, incorrectly conceptualizing the public landlord as if it, too, was a private individual firm. What continued to bother me was what is or ought to be the structure, role, and behavior of a public landlord in the governing analytical theory? I never figured that one out and, so far as I am yet aware, no one else has either.

I know of only two exceptions to that statement. One is our colleague, a fellow of this Association, Marion Clawson, who, in his 1951 book, *Uncle Sam's Acres,* extensively analyzed the role and conduct of the federal government as land owner and manager but gave only passing attention to its role as landlord. The other exception was the Public Land Law Review Commission, which in its monumental task reported in 1970 gave some attention to the federal government-private user relation on the federal lands.

It was at least a dozen years later that I had my next illuminating experience contrasting conventional economics and my land economics. I was traveling in Australia in the early 1960s. I struck up an acquaintance with a senior agricultural economist in the Australian Bureau of Agricultural Economics. We were visiting about a variety of professional matters of mutual interest revolving around policy issues related to land economics. We got into a discussion of agricultural product price supports, particularly the issue of whether or not one should and, if so, how one should incorporate land values into the "base" from which the magnitude of such supports should be calculated. He related his unsuccessful experiences in trying to convince the Ministry, the Parliament, and producer groups that land values should not be included in the base. The gist of his argument was that (*a*) such a land value is usually taken to be a "fair market value" for each individual producer's land such as might be generated by a willing seller and a willing buyer negotiating in a land market, these individual parcel market values then being extrapolated to all agricultural lands of similar economic qualities. But (*b*) such market land values are derived from the "private rents" the parcels generate, capitalized to a private myopic time horizon at private individual discount rates, the land's rent being affected by private individual opportunity costs for the operator's management, labor, and capital and by the prices received for the land's products and prices paid for inputs. However, the level of product prices, hence the land's rents, will be affected by the very supported prices the level of which the supports are designed to maintain, usually even to increase. Thus, (*c*) the aggregate value of individually determined land values will be affected by the circularity between the level of supported product prices and the underlying land values, each augmenting the other without any clearly determinable limit. Thus, (*d*) to break that circularity, it is necessary to separate the land value base from individually realizable rents and capitalized values generated in the market place.

But, upon breaking that relationship between supported price, level of rent, and individual land parcel value, what value do we put in its place in the support formula for product prices? Seemingly, such a value would be some aggregate social value of the national aggregate of agricultural lands related to some optimal or improved level of aggregate well-being capitalized to some "long-view" time horizon at some "social" discount rate.

That raises difficult, maybe even impossible, conceptual as well as operational problems. Just what is the socially relevant level of aggregate agricultural land values? What is the value of a homeland, of the socioeconomic base for a society? We did not know then, and I do not know now. But the impact on me was, I think for the first time, a clear realization that the "value" of the social aggregate is not simplistically the simple aggregate of individual values; the aggregate is not, likely, the simple sum of its parts. But what is it?

Not long after, again in Australia, I again ran into the same paradox in a much sharper and more revealing context. The island of Nauru in the Southwest Pacific has been found to be composed of highly rich phosphates. The technical development of fertilization in agriculture led to a fantastic growth in market demand and in price for this natural resource. So, of course, the Nauruans were quick to take advantage of it and entered into contracts with Australian, New Zealand, and other Southwest Pacific governments to sell their

phosphate in the ground at a negotiated rent price that has greatly raised the level of living and welfare of the Nauruans. Until, as you may surmise, they realized that their island homeland would fast become a hole in the sea! What then? Well, of course, they began raising to ever higher and higher levels their asking price (and getting it) per unit of homeland removed. But that has not exorcised the devil. For after all, they either must sell their homeland piecemeal, in order to live as they have become accustomed to live, ultimately moving to some other as yet unacceptable and unlocated alien environment or, by protecting the permanence of their homeland, to live in previous poverty.

Is the aggregate value of their homeland the tonnage of phosphate they "own" times its market price per ton? If not, what is its value? Again, the maximization of the market value of their natural resource is not necessarily, is probably much less than, the aggregate social value of the homeland. Here again, the aggregate is clearly not the market sum of its individualized parts. What "support price" for phosphate should the Nauruans adopt? I still do not know the answer. I am not yet sure I even know how to conceptualize an answer.

Over the years I have enjoyed telling the story of the "Nauruans' Dilemma" to confound my classes, but not until I read Kenneth Boulding's 1966 paper "The Economics of the Coming Spaceship Earth" did I begin that restructuring of my conception of natural resource economics that pointed the direction that resolution of the paradox must take and began that intellectual process that ultimately allayed my intellectual frustrations by finding how to merge the conceptualizations of natural resource economics with the conventional wisdom of economic science. This was the climax point in my intellectual evolution. During the ensuing decade I have been filling in and filling out that conceptual amalgamation.

Just what did Boulding say that brought about in me this intellectual revolution? I quote:

> We are now in the middle of a long process of transition in the nature of the image which man has of himself and his environment. . . . The image of the frontier is probably one of the oldest images of mankind, and it is not surprising that we find it hard to get rid of.
>
> Gradually, however, man has been accustoming himself to the notion of the spherical earth and a closed sphere of human activity. . . . Even now we are very far from having made the moral, political, and psychological adjustments which are implied in this transition from the illimitable plane to the closed sphere.
>
> Economists in particular, for the most part, have failed to come to grips with the ultimate consequences of the transition from the open to the closed earth. . . .
>
> The closed earth of the future requires economic principles which are somewhat different from those of the open earth of the past. . . . [The open economy is characterized by] the illimitable plains . . . associated with reckless, exploitative, romantic, and violent behavior. . . . The closed economy [on the other hand is one] in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy. The difference between the two types of economy becomes most apparent in the attitude towards consumption. In the [open] economy, [of the conventional wisdom, i.e.,] consumption is regarded as a good thing and production likewise; and the success of the economy is measured by the amount of the throughput from the 'factors of production,' a part of which, at any rate, is extracted from the reservoirs of raw materials and noneconomic objects, and another part of which is output into the reservoirs of pollution. . . .
>
> By contrast, in the [closed] economy, throughput is by no means a desideratum, and is indeed to be regarded as something to be minimized rather than maximized. The essential measure of the success of the economy is not production and consumption at all, but the nature, extent, quality, and complexity of the total capital stock, including in this the state of the human bodies and minds included in the system. . . . This idea that both production and consumption are bad things rather than good things is very strange to economists, who have been obsessed with the income-flow concepts to the exclusion, almost, of capital-stock concepts. . . .
>
> There are problems here which the economics profession has neglected with astonishing singlemindedness (Boulding 1966, pp. 3–11).

Elsewhere, Boulding (1970) elaborated this theme further:

> . . . the real measure of economic welfare is not income at all. . . . Income is just the unfortunate price that we have to pay because the state [of the person or of society] is corruptible. . . . Consumption is a bad, not a good thing; production is what we must undergo because of consumption. . . .
>
> Much more fundamental is that all of economics, the whole GNP [gross national product] mentality, assumes that economic activity is a throughput, a linear process from the mine to the garbage dump.

> The ultimate physical product of economic life is garbage . . . a great deal of man's activity is directed toward what we might call desired pollution. . . .
>
> If the earth is to become a spaceship, we must develop a cyclical economy within which man can maintain an agreeable state.
>
> Under such circumstances the idea of the GNP simply falls apart. We need a completely different set of concepts for that eventuality, and we are still a long way from it technologically because we never had to worry about it. . . . Suddenly, it is becoming obvious that the Great Plain has come to an end and that we are in a very crowded spaceship. This is a fundamental change in human consciousness, and it will require an adjustment in our ethical, religious, and national systems which may be quite traumatic (pp. 161–64).
>
> Economic development is the process by which the evil day is brought closer when everything will be gone (p. 166).
>
> I have recently discovered the real name of the devil, which is something terribly important to know. The real name of the devil is *suboptimization,* finding out the best way to do something which should not be done at all. . . .
>
> The problem of how to prevent suboptimization is, I think, the great problem of social organization. The only people who have thought about it are the economists, and they have the wrong answer, which was perfect competition. Nobody else has any answer at all. Obviously, the deep, crucial problem of social organization is how to prevent people from doing their best when the best in the particular, in the small, is not the best in the large (pp. 169–70).

So, according to Boulding, the conception of earth as spaceship rather than as limitless plain will require traumatic adjustment in our ethical, religious, and cultural systems—and, according to me, in our relevant intellectual systems as well, which includes conventional economic wisdom and will be equally traumatic to us! But paradoxically that conceptual shift set in motion within me the evolution in my intellect that relieved the unconscious traumatic tension I had lived with for decades. Why had it not been possible all along to integrate neatly land economics as I knew it with the conventional economic wisdom that I also knew?

Incompatibility Between Natural Resource Economics and Conventional Economic Wisdom

If one defines "land" (in land economics) or "natural resources" (in natural resource economics) as semantically equivalent to the "natural environment" or to "nature" (which I do) and if one conceives nature as a closed system (which it is), then natural resource economics stands conventional economic theory and the conventional real world wisdom of the economy on their respective heads—upside down, which is very upsetting indeed—and the intellectual trauma migrates out of my mind to enter the minds of those who espouse the conventional economic intellectual wisdom. Why?

Conventional economic intellectuality posits individual economic units as producers and as consumers acting within a system constrained by conventional economic institutions of which the market, competition, prices, and individualized property are the principal elements. That conventional intellectuality sets as its objective function the maximization of income, of throughput, per capita per unit of opportunity cost. In that conventional intellectual construct, the preference sets of the individualized actors and the environment of institutions that constrain and direct their actions are posited as exogenous constants. The aggregate of incomes, which is to be maximized, is taken to be the sum of the optimal individualized net gains generated within the interacting system of individualized actors choosing within the constraining envelope of exogenous preference sets and market institutions.

It is just here that the closed system conception of nature as interpreted and imposed by natural resource economics gets in its upsetting licks, its upside-down trauma on the conventional system. Maximization of throughput within constant exogenous parameters of preferences and institutions and within an individualized myopic time frame is no longer the relevant desideratum. This is Boulding's suboptimization devil. In its stead, maintenance or improvement in the state of the capital stock and of the bodies and minds of the aggregate system within a long-run (even infinite) time frame wherein there is no "outside," only "inside," is the required desideratum.

Even what we economists have known since Keynes as "macroeconomics" is not truly "macro" as defined by natural resource economics. The Keynesian "macro" is concerned with behavior of aggregate throughput of the conventional system, which is composed of interacting "micro" units guided by the conventional system of relevant preferences and established institutions. It has noth-

ing to say about the physical constraints of a spaceship nature on the macro system nor about the conventional sets of preferences and institutions other than as they are fiscal, financial, and market related.

Defining the problem of economic well-being viewed through the lens of natural resource economics in addition to that of conventional economic wisdom shifts the analytical "line of sight" away from exclusive concern with system throughput to concern for well-being state of the system, away from exclusive attention to preference sets that emphasize satisfactions derived from marketable products to concern for preference sets that emphasize satisfactions derived from inner resources of the person, derived from consumption of marketable products from flow rather than stock resources, and toward satisfactions derived from magnanimous sacrifices made to keep the society's future options open. It also shifts the "line of sight" away from exclusive concern with exogenous conventional institutions of property and away from exclusive concern with structure, conduct, and performance of the competitive market. Natural resource economics also shifts the "line of sight" of economic analysis away from research, education, and the adoption of technology to enhance throughput of marketable products derived from the conversion of resources to garbage and towards research, education, and the adoption of technology to enhance the state of well-being of the system derived from production and consumption based on flow resources and on the reconversion of garbage into productive inputs, together with minimization of the entropic dissipation of energy.

A big order? It is a terrifyingly big order, but one on which nothing less than the permanent viability of mankind as humankind, even possibly as a biotic form, depends absolutely. I am not so brash as to argue that the upside-down conversion of conventional economic wisdom that this formulation of the problem implies must be effected today—or even tomorrow. But the time horizon of tomorrows within which the inversion must be effected is frighteningly close. Apocalypse is too close for comfort!

Imposing the structure of ideas that is natural resource economics upon the conventional economic analytical wisdom requires that preference sets and the institutional environment of the conventional wisdom be transposed from exogenous analytical constants to endogenous variables, that problem resolving analyses focus on the means whereby purposeful change can be effected in those preference sets and in that institutional environment, that research, education, and technology increasingly deal with the structure and role of relevant institutions, and with means for their purposeful reformulation that will guide "as by an invisible hand" improvement in the well-being state of the system.

No Need for Natural Resource Economics in Conventional Economic Wisdom

I now know that my past intellectual discomfort over the relations between land economics and conventional economics arose because there is no need or place for natural resource economics as a distinguishable body of ideas within the conventional structure of economic analytical wisdom. In that conventional structure there are only capital and man; there are only production and consumption economics and the market economy; there are only firms, consumers, and financial and fiscal institutions; there are only individualized entities interpersonally related through competition.

Our late colleague, a former president and fellow of this Association, Karl Brandt, has said, "A further factor that determines the effective capacity of an economy is popularly called natural resources. Their nature, their role in economic growth, and the importance of specific types of resources change with the progress in science and technology and the shifts in domestic and foreign demand. Contrary to popular notions, these resources have no value as such. They represent opportunities to apply management, labor, and capital to them for the purpose of deriving energy or materials from them. Once public or private capital or both have made natural resources accessible or productive, these resources become valuable" (p. 33). In that last sentence, Brandt might have said that natural resources so conceived become capital. For, in the analytical construct within which he was reasoning, that of conventional, individualized market-oriented, throughput economics, that is what natural resources are—capital goods.

Our eminent colleague, Earl Heady, also a fellow of this Association, has said, "Land, as a factor of production, has no unique charac-

teristics which should cause it to be set aside by itself in economic analysis. . . . Land differs from certain other factors in respect to legalistic and institutional characteristics. . . . Analysis which relates to institutions *per se* has come to be known as land economics. Most institutions do, however, have impacts which lend themselves to analysis via economic tools drawn from the basic principles of production, distribution, pricing, and consumption. No new principles unique for land can or need be formulated. . . . Land perhaps takes on unique importance only in respect to its use and allocation over time . . ." (p. 763).

Brandt and Heady are both correct in what I have quoted given the conceptual economic analytic framework within which both were working. Both are here concerned with questions of "production, distribution, pricing, and consumption" (to quote Heady) as they emerge in an individualized actor, competitive market system from which maximized throughput efficiency can be analytically deduced. Heady correctly states that "land" as a factor of production has no unique characteristics for analysis, that it differs from other factors in legalistic and institutional ways, and that land economics embraces analyses of "land" that relate to institutions per se. As production economic analysts, he and Brandt were right when one recognizes the implicit framework of conventional "classical" economic maximizing or optimizing of throughput employed by both. But this is Boulding's partial optimization "devil" again if and insofar as it is used to analyze alternative economic policies as handmaiden to the social process of policy making for natural resources to enhance the state of well-being.

As Heady correctly observes, natural resource economics is uniquely (I would say inherently) institutional. So soon as one incorporates the uniquely institutional natural resource economics together with the uniquely "spaceship" conception of nature into the conventional economic analytical construct, the conventional system experiences a transformation—it becomes applied institutional economics; it concerns itself first with maintenance or improvement of the well-being state of the system rather than with maximization of the throughput of the system and, second, with minimization of natural resource input in state maintenance or improvement rather than with optimization of natural resource input consonant with efficient throughput maximization. To paraphrase Boulding, it stands conventional economic wisdom on its head.

Reverting to the story of my personal frustrations, the Boulding thoughts (quoted above) provided the intellectual cue that put me on the path to my tension relaxation. I do not mean to imply that I did it all on my own following the Boulding cue. For that was but the cue that gave me the conceptual insight that opened my eyes and mind to the significance of the flood of writings by many others over the past two decades—on externalities and market failure, on Pareto-relevant and Pareto-irrelevant criteria, on property rights and economic behavior, on "collective action in control, liberation, and expansion of individual action" (to quote Commons 1934, pp. 69, 73, 902; 1950, pp. 15, 21, 26, 343) relative to the development, depletion, use, and transfers of use of natural resources as they affect the state of aggregate economic well-being over time.

Policy Analyses, Uncertainty, and Conventional Economic Optimizing

Policy making for natural resources, or for anything else for that matter, is indubitably future looking. Hence, it is inherently uncertain. Policy making and any economic analysis meant to assist it must recognize this fact of futurity uncertainty. There can be no operational analytical optimum for the long run. There can be only suboptima for the short run constrained by the promise—or hope—that they will improve well-being in the long run. Such inherent futurity uncertainty dictates that greater importance be given even in the short-run objective function to reversibility of any policy actions posited than to their optimization. Ability to "back up" and try something else in the succession of short runs is more important than is a constraining demand for optimizing even in the short run, let alone for the long run.

This demand in policy making and its underlying economic analyses for short-run improvement in well-being rather than for optimizing and for reversibility of actions as a constraint on short-run policy choices led Lindblom (1959a, b) to conceptualize policy making as marginal incrementalism and to his characterization of the process as "muddling

through." The reversibility constraint upon policy choices is necessary, else over time some options will be closed, some future alternatives denied, some opportunities for improvement in well-being destroyed forever. Thus, economic analyses useful to policy action must formulate their objective functions in improvement or betterment terms and must build into their analytical models the opportunity costs of any irreversibilities in the array of alternative policy actions explored.

Property in Natural Resources, Monopoly, and Competition

An economic system containing individualized ownerships of natural resource parcels is inherently a monopolistic system. It introduces into conventional individualized economic optimizing implicit monopolistic aberrations in the economic results of the system due to the ubiquitous presence of externalities and public good elements, the nonreproducibility of stock resources consumed in production, and the presence of those unearned, surplus incomes called rents, which are not eliminated and may even be accentuated by competition. Serious questions can and have been raised regarding the private maximization and capture of these natural resource rents that are at bottom monopolistic returns. Individualized property clothes the holders of individualized natural resource parcels with rights and liberties that give them economic power and freedoms of action vis-à-vis others relating to each particular unit of space, the resources it contains, and the products it can be made to generate. Obviously, the degree of monopolistic power with which individual natural resource property holders may be clothed is widely divergent in magnitude and often is very small. But whether such monopolistic power bestowed on parcel owners is large or small, to that degree it distorts both economic efficiency and equity outcomes from what they would be if the idealized competitive conditions of conventional economic theory were to prevail instead.

But of greater implication for economic policy and more upsetting to purist purveyors of the conventional economic wisdom, the solution for such monopolistic aberrations in aggregate well-being growing out of individualized property in natural resource parcels will not be found in the elimination of those monopolistic elements but rather by their extension to more inclusive collectives. Such extension of monopolization is the real meaning of actions taken to "internalize externalities" and to further the production of "public goods." Maximization of the state of well-being of the society often requires a "monopoly solution" of the natural resource problem. Since monopolization of natural resources by private individuals is politically unthinkable given our present social values, such monopoly solutions require collectivization solutions that range from private collectives such as cooperatives to quasi-public and truly governmental monopolies. Here, again, the natural resource-based problems of aggregate well-being stand the conventional solutions of economic wisdom upside down. Rather than the perfect competition of conventional economic wisdom, natural resource problems often require the opposite—broadened collectivist, monopolistic solutions!

The intriguing thing about this is that John Stuart Mill and Henry George saw it clearly 100 to 150 years ago! Why have their insights been so universally ignored, so single-mindedly ignored by economists (to paraphrase Boulding)?

The answer likely lies in what the historian, Walter Prescott Webb in his book, *The Great Frontier*, refers to as the 400-year boom in modern history:

> What was the essential character of the frontier? *It was inherently a vast body of wealth without proprietors*. . . . When this great area was made available to the crowded and impoverished people of the Metropolis [by which he means western Europe], they swarmed out like bees to suck up the nectar of wealth, much of which they brought home to the mother hive. *This sudden, continuing, and ever-increasing flood of wealth precipitated on the Metropolis a business boom such as the world had never known before and probably can never know again. . . . Assuming that the frontier closed in 1890 or 1900, it may be said that the boom lasted about 400 years.*
>
> . . .
>
> Assuming that there was a boom, and that it lasted 400 years or more, it follows that a set of institutions, economic, political, and social, would in that time evolve to meet the needs of a world in boom. . . . [T]hese boom-born institutions, economic systems, political systems, social systems—in short, the present superstructure of Western civilization—are today founded on boom conditions.
>
> . . . scholars will look back on the age when the Golden Door opened, and men marched out to the Great Frontier to create the greatest boom that the world has known; they will make myths and legends

about it, and in poetry and literature express their poignant yearning for New Frontiers. They will see the frontier as the great factor in the age called modern, see it clearly as the lost factor which they would so love to find (pp. 13–28).

Conventional economist writers today sound that "poignant yearning," though they express it in economist's rather than historian's language. They call it "economic growth."

Natural Resources and Economic Growth

It is some (but not very much) exaggeration to say that ever since man emerged as a human animal, and particularly during the 400-year boom, economic growth has been the prime solver of his economic welfare problems and has constituted one of the primary foci of public policy and social inventiveness. Economic growth provided the additional real—or throughput—income for additional persons as populations grew, provided the throughput surpluses from which flowed expanded investment in nonhuman and human capital alike, and financed technological change as well as the leisure time for pursuing philosophy, science, and the arts. Economic growth fueled explorations both in the domain of the mind and of the world; it provisioned the efforts by which newly opened vistas of mind and of world were occupied and developed. Economic growth made possible the explorations of mind and world and the exploitation of that which these explorations discovered.

Seldom has the value of economic growth to man and to his quest for a better and happier life been questioned. So basic has it been to man's beliefs that the philosophical systems that underlie his value systems and the social, economic, and political institutions that he has developed and that guide his modes of living are all designed to rationalize, facilitate, and glorify economic growth. It has been the great problem solver and the values and institutions of organized societies have been designed to insure that it will remain so.

Primary among these values and institutions have been democracy, capitalism, and individualism and the individualized private property in nature, the free markets, and the competition that characterize our conventional economic wisdom. These values and institutions of the 400-year boom were entirely consistent with man's view of the world as if nature's storehouse of productive resources was infinite and the capacity of her dumps and sinks to receive, store, and recycle waste products was also infinite. These values and institutions were wholly consistent with the goal of maximized throughput. Economic growth was the perfectly logical desideratum of the good and right.

Small wonder that the penetrating insights of Mill and of George—insights that saw nature as a limited and closed rather than as a limitless and open system, that saw the shortcomings in individualized property and competition in the resources of nature, that saw the dangers in, even the impossibility of, endless economic growth and the inevitability of lesser, even stationary growth—were joyously ignored in the tumultuous excitement of the 400-year boom.

As so well and succinctly put by Barkley and Seckler in their excellent little book, *Economic Growth and Environmental Decay—The Solution Becomes the Problem*, the conventional solution to the well-being problem—economic growth measured in throughput terms—has itself become the problem demanding solution if we are to realize the well-being maintenance or enhancement goal in the face of natural resource depletion in the spaceship that is nature.

I, too, was an intellectual creature of that boom. But my land economics had generated in me a nagging schizophrenia, a dual personality, together with, if not discord, at least dissonance between those dual sides of my intellect. I well remember the intellectual euphoria I experienced a dozen years ago upon first reading that trenchant work by Barnett and Morse, *Scarcity and Growth: The Economics of Natural Resource Availability*, from which I superficially gleaned the conclusion that natural resource scarcity need be no restraint on continuing economic growth given all the many ways that our economic system, even in the absence of technological change, can and will mitigate, even eliminate, resource restraints on growth. In defense of Barnett and Morse, I hasten to add that a more careful reading of their work—particularly in the context of a more encompassing natural resource economics on my part that recognized the basic and fixed restraints of space and energy in the spaceship earth, together with a greater awareness of the quality of life parameters in the objective function—destroyed my euphoria but led me to see that amalgamation of natural resource economics with the conventional economic wisdom upsettingly altered the latter, not the former.

Then in our western society came the upsetting environmental revolution of the 1960s and the more upsetting energy crisis of the 1970s. Now, not only I and numerous other intellectuals but increasingly numerous citizens have been jarred out of their complacent euphoria with economic growth and the limitless quantitative expansion of mankind and his consumption. Not only intellectuals but many citizens, too, suddenly confront the closed spaceship reality that is nature and the devastation that that confrontation inflicts on the conventional economic wisdom and its derivatives—democracy, capitalism, and individualism particularly as they relate to individualized property rights in nature and to free markets and competition in natural resources and their primary products.

I do not argue that all economists should be natural resource economists. That would be inexcusably smug egocentrism. I intend no more here than to describe how natural resource economics led me to a clear and critical appraisal of the future usefulness of the conventional economics on which I and all of us have been nurtured. Remember that I said this paper is a personal testament.

But I certainly do argue that all of us in our economic analyses, especially where and when they have public policy relevance, must incorporate in our analytical structure the conception of the closed spaceship earth, improvement in the well-being state rather than maximization of the throughput of the system, together with all relevant preference sets and institutional elements as endogenous variables rather than as exogenous parameters. Doing so places clear restraints on conventional economic wisdom as a vehicle for optimizing well-being or improving the state of the dependent society.

Doing so will not be easy, nor always comfortable. I close by quoting the closing paragraphs from John Kenneth Galbraith's book, *Economics and the Public Purpose*:

> . . . the future of economics could be rather bright. It could be in touch with the gravest problems of our time. Whether this is so—whether economics is important—is up to the economists. They can, if they are determined, be unimportant; they can, if they prefer a comfortable home life and regular hours, continue to make a living out of the infinitely interesting gadgetry of disguise. . . .
>
> Or economists can enlarge their system. They can have it embrace, in all its diverse manifestations, the power they now disguise. In this case, as we have seen, the problems of the world will be part of their system. Their domestic life will be less passive. There may be a contentious reaction from those whose power is now revealed and examined. And similarly from those who have found more comfort than they knew in the fact that economists teach and discuss the wrong problems or none at all. But for a very long time to come economists will thereby escape the fate that Keynes foresaw (pp. 323–24).

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The Economics of Agriculture and Agricultural Economics

Emery N. Castle

During this past year those of us who work at Resources for the Future (RFF) were stimulated by the external Research Advisory Committee to identify the most important problems that will face society in the next twenty-five years. The RFF experience provided background for the preparation of this paper. My end objective is to assess agricultural economic's professional posture relative to the environment in which we find ourselves. But that is the second part. In the first part my purpose is to say something about the social environment itself. Of course, this is really only another way of describing the most important social problems that I expect to dominate the next quarter century.

Social Environment

I have found the work of my colleague, Edgar S. Dunn (1971, 1975), to be exceedingly useful in describing the social environment. According to Dunn, the bulk of species adaptations in bioevolutionary history has been specializing; that is, they bring about a highly specialized correlation of population behavior with the requirements of a restricted environmental niche. In contrast, adaptive generalizations occur less frequently and widen the environmental range within which the species operates. The unique feature of the genus *Homo* is that it has made a series of generalizing adaptations. Organized markets, the city, and the alliance of institutional science with technology are examples of generalizing adaptations. The reason that humans have made generalizing adaptations, rather than specializing in response to the natural environment, has been because of learning processes that have amplified the productivity of human behavior.

While little may be known about the process that gives rise to successful adaptations, a substantial amount is known about some of the adaptations themselves. Economists, for example, know a great deal about markets and their operation. The market is one of the most powerful of the generalizing adaptations that has been made by modern man.

I now identify four characteristics of the contemporary scene that will have influence on the economics of agriculture and the practice of agricultural economics. These four characteristics are global in nature. Therefore, much of what follows is presented in an international context.

The Presence of Social Irreversibilities

Although the concept has been around a long time (Ciriacy-Wantrup 1952), current environmental awareness has stimulated interest in distinguishing among decisions with respect to whether or not they are reversible and, if so, the cost of reversibility. The concept may have even greater relevance as applied to social processes.

The benefits of modern technology, that is, successful adaptations of knowledge, have been enormous. Individual mobility, individual development, and an increased life span are examples. Those who have achieved these benefits will not yield them easily or willingly. Those who have not achieved them, but who observe that others have, aspire to them.

For this reason past successful adaptations cannot be reversed. New adaptations, yes, but a reversal, no, unless there is a major social collapse. This is why much of the writing on life style, no growth, and "small is beautiful" is intellectually barren. Those who argue for these alternatives to present adaptations fail to deal with the loss of these real or perceived

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Invited address.

Emery N. Castle is senior fellow and vice-president, Resources for the Future.

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benefits (American Academy of Arts and Science).

For the same reason, some of the discussion about world agriculture is unrealistic. Attempts to develop and force the adoption of technology tailored toward a subsistence agriculture, a solution of the problems of the poorest of the poor, or energy "extensiveness" is not well grounded in either fact or logic. The technology that is found to be useful reflects relative factor costs, and technology that does not hold the prospect of obtaining for the adapters the benefits of general economic progress does not have a bright future (Hayami and Ruttan; Darmstadter, Dunkerley, and Alterman).

Yet we are foolish if we believe there are no problems to be encountered by extrapolated past growth (Brubaker 1972, 1975). The undesirable side effects of continued application of particular technologies, the exhaustion or more complete utilization of certain resources held in common for which there are not ready substitutes, the possibility of diminishing returns in some productive processes, and the existence of people bypassed by economic change cannot be dismissed out of hand. The fears and concerns that have led to talk about "no growth" and "life style" reflect legitimate concerns even if many of the proposed solutions are unrealistic (Cadell).

The Divergence of System Objectives and Performance

Both bureaucracies and markets are ubiquitous in contemporary life. Yet not all of the responses from such social creations are socially desirable (Bator, Niskanen).

Social control is made difficult by the fact that the best utilization of a certain technology often requires that it be applied over wide areas affecting many people. But effective participation in decision making increases in difficulty as the number of people increase. This is a current fundamental problem. On the one hand, the utilization of certain technology or knowledge requires large organizations, such as a national government, a multinational corporation, or an international research and information exchange network. On the other hand, the full consequences often cannot be effectively dealt with at this level because of the inability of social control mechanisms to reflect general understanding and interest.

The Divergence of Anticipated and Realized System Performance

As noted, contemporary society is distinguished by various kinds of large social organizations that interact and intersect at many different points. Yet, the performance of this complex cannot be predicted with confidence. This lack of confidence in our ability to predict threatens social cohesion. I break this problem into two parts to make the meaning clear.

The construction of large system computer models has progressed rapidly in recent years. These models typically incorporate knowledge from many disciplines about various cause-and-effect relationships, but the results obtained are often counter to the expectations derived from disciplinary theory. It can be argued, quite logically, that something like this can be expected because no one intellectual discipline can represent all of reality. In addition, the integration of knowledge, with a reflection of appropriate interdependencies and with an accounting of recursive relationships, should lead to better predictions. There are also many reasons why such models may not be accurate predictors of system performance. Furthermore, adequate tests of such predictions cannot be made. Thus, a situation exists where there is good reason to doubt predictions made either on the basis of disciplinary knowledge or the most complex of computer models. (For a most thoughtful discussion of this general problem, see Day and Koenig.)

But the world is not in the hands of experts, disciplinary or otherwise. The lay person who is called upon to make a political judgment must also have a hypothesis about cause-and-effect relationships, which may or may not conform to actual performance. In response to a question, Patrick Cadell, President Carter's pollster, said, "But you are right; in the world I deal with, perception is reality. What the public believes is what is operable." Thus, the expectations that social scientists and other experts have about complex social systems often differ from the expectations of the lay person, and neither may be in accord with reality. While the phenomenon itself is not new, the consequences become more serious with

increase in size and complexity of social organizations; the impact on social stability is obvious.

The Intersection of Social and Natural Systems

The agricultural production function has at its base biological science. This has long been recognized in farm management and production economics, and to their credit agricultural economists have done pioneering work integrating production functions with the economics of the farm firm.

This work does not, however, touch the essentials of the emerging issues that impinge on sustained economic production. So long as aggregate effects could be ignored, production relationships could be expressed in terms that were relevant to firm decision making. Thus, new knowledge and capital could be substituted for "land" over a relevant range, and it was not necessary, indeed it would have been foolish, to have concerned ourselves with the possibility of finiteness of natural resources.

The scarcity of those natural resources that are priced in the market place is not the most pressing concern. Rather, the greatest threat comes from a different direction. Numerous resources are not priced in the market place, and these resources are typically referred to as common property. Because they are not priced, incentives do not exist for the development of technology that can be substituted for such resources. It is these resources that are becoming limiting to improvement in human welfare. Examples are the atmosphere, open space in urban areas, and certain natural systems.

This signifies that social science theories need to reflect more adequately natural systems. The relevant formulation of the aggregate production function may need to be in terms of the fundamental concepts of biological and physical science.[1] Until this reformulation occurs, I am not optimistic about scientists developing appropriate institutional devices for common property management. Of course, society may discover such devices through adaptation processes independent of organized social science.

[1] Georgescu-Roegen's *The Entropy Law and the Economic Process* is an attempt to provide a more general formulation of production relationships.

Summary

Dealing with the four characteristics of contemporary society discussed above constitutes the most important problem facing us for the next quarter century. But what has been said to this point that is of value in understanding the nature of contemporary economics of agriculture?

(*a*) Agricultural production around the globe will become increasingly commercialized. This commercialization will not solve the problems of the poorest of the poor except indirectly.

(*b*) Economic progress, made possible by agricultural improvement, will continue to cause social disruption. Unless there is a social collapse, however, society will not turn its back on large firms if it is economically efficient to be large. The benefits of economic development are such that those who are now deprived will strive for them; those who have the benefits will not willingly surrender them.

(*c*) Two types of negative side effects of economic growth will demand increased attention. One is social disruption; the other is reflected in insults to the environment. The identification of the most appropriate techniques for reflecting those side effects in decision making will be an increasingly important social problem.

(*d*) An international responsibility for hunger exists largely because of the transmission of information across national boundaries. National agricultural policies will be subjected to greater international scrutiny, and it will be difficult to isolate these policies from international relationships.

(*e*) The economics of contemporary agriculture will continue to be concerned with multiple objectives. Income distribution objectives will be counterproductive if production incentives are ignored. There are many agricultural examples of this from around the world, but if one does not wish to look abroad, U.S. energy policy provides an excellent example close to home.

Agricultural Economics

This section is normative. Here, I evaluate the performance of a profession and offer recommendations. Agricultural economists currently face some of the most severe problems we have had since I have been a member of

this profession. The trends and problems described above demonstrate that the economics of agriculture is becoming increasingly interdependent with other social problems. The result is that many groups, other than the agricultural economics establishment, are concerning themselves with the economics of agriculture. There is a real danger that agricultural economists may become the technicians for microeconomic problems but that we will lose our preeminence in policy matters. The remainder of the paper elaborates this concern.

In the following pages an attempt is made to evaluate an institution, to do what economists talk about so much but for which they have inadequate methodology. Ad hoc criteria used in this task are described in detail in the appendix. To summarize, these criteria are (*a*) the adequacy of the institution in defining its domain of performance (this criterion is concerned with who is included and excluded from the performance of the institution); (*b*) the precision of the institution in specifying the relation of those who make decisions to those who bear the impact of decisions; (*c*) the effectiveness of the incentive system of the institution in bringing about desired behavior; (*d*) the capacity of the institution to respond to change; and (*e*) the ability of the institution to generate relevant information.

Capacity to Define a Domain of Performance

During the past two decades agricultural economists have become applied economists by working on a wide range of problems. If one believes that what agricultural economists do is more important than what they call themselves, we can take justified pride in our willingness to tackle new problems. This proceedings issue, for example, reflects urban planning, agribusiness, marine economics, and international affairs as subjects of interest and emphasis.[2] Furthermore, the planning of annual AAEA meetings better reflects the wishes and desires of the current membership than did the meetings of an earlier time because of a few, relatively simple, changes in institutional devices.

[2] George Tolley and Irving Hoch, agricultural economists, are two of the most respected researchers in the subdiscipline of urban economics. The proceedings of this meeting will reveal the leadership of agricultural economists in marine economics. There is evidence that forestry economics may be on the verge of a renaissance. If it is, the efforts of an agricultural economist, Marion Clawson, will prove to be significant.

There are those who argue that agricultural economists have encompassed greater breadth than can be adequately accommodated and that the traditional fields of agricultural production, distribution, and policy have been neglected. Without doubt these central problems of agriculture should be readdressed. However, questions can be raised as to whether a continuation of the studies that dominated the 1950s and 1960s would have left us significantly better off than we were in the early 1970s. Indeed, it may now be easier to reorient our research and education to the contemporary economic problems of agriculture than it would have been if we had continued to work within the paradigms of the 1960s.

The research approach used by agricultural economists has been far more stable than the problems that have been addressed. The essentials of this approach have been a concern with the empirical and an appreciation of both the power and the limitations of economic theory. These dual characteristics have supplied our unity and permitted us to work effectively in fields ranging from urban to marine economics.

I am pleased with the domain of agricultural economics subject to the institutional framework within which we operate. We have been pragmatic in the problems studied, but we have been unified with respect to the way they have been studied.

Relation of Decision Makers to Those Who Bear the Impact of Decisions

Agricultural economics as a subdiscipline owes its development to the nurture provided by the land grant universities and the U.S. Department of Agriculture. The nature of the extension and research program insures a degree of responsiveness and accountability to clientele needs. The nature of these institutions also establishes and circumscribes clientele groups to a very considerable extent. While the impact of research and service extends beyond these clientele groups, our principal area of accountability has been to them. The evidence suggests that the profession has been commendably responsive to the needs of these clientele groups in research and service. It is not clear that we have been as responsive to the needs of other groups who have been affected by the total agricultural research and education establishment.

There are some special problems, however, that exist with respect to graduate education. Of all of the activities of the typical department of agricultural economics in a land grant university, graduate education most nearly approaches the concept of the autonomous university; yet the research that is being performed by such departments is becoming increasingly short run and applied in response to "accountability" needs. Does this form a satisfactory base for graduate education?

Breimyer recently said we may be guilty of glamorizing certain subareas of agricultural economics with the result that these are overloaded while others are undersupplied. Breimyer's view of graduate education seems to be sharply at variance with that of Ruttan, who wrote that the most able graduate students tend to gravitate away from those areas that are experiencing consolidation and refinement and toward those experiencing new bursts of insight. This divergence of view turns on whether graduate education can or should be manipulated and molded in response to applied research needs or whether it will be more valuable if it is conducted in a more autonomous fashion.

As stated above, the elements that provided the unity of agricultural economics are a concern with the empirical and an appreciation of economic theory. If this unity is to be preserved, graduate education needs to continue to provide for such an orientation. In this connection, I raise two warning flags.

First is the failure to distinguish between quantitative techniques and an empirical orientation. The purpose of empirical work in science is to permit the researcher to better analyze reality, but many of our quantitative techniques have no relation to this role. They may be normative, as in the case of much programming work, or they are futuristic, as is true of many system dynamics models. Such results are often incapable of being tested against past or future experience. Even where some testing might be done, it often is not. Thus, the technique, instead of being a more powerful tool for analyzing experience, in effect isolates the researcher from reality. While agricultural economists have a justified reputation for empirical work and confronting their conjectures with reality, preoccupation with quantitative techniques does not assure this. Indeed, overemphasis on techniques with built-in normative assumptions may preclude it.

Second, the analytical framework of economics properly qualifies it as the social science of the greatest value in policy analysis. Yet the mechanical application of economic theory to the kinds of issues and problems identified in this paper is not likely to be fruitful (Roberts). To maintain their traditional appreciation of both the power and the limitations of economic theory, agricultural economists may need to follow more closely than they have developments in the mainstream of economics. Most agricultural economists do have a fairly good command of microeconomic theory through their graduate training. Too frequently, their association with general economists is minimal after that. Both groups are the poorer as a result.

Educational experience at the graduate level can be classified into four major groups: (*a*) economics and agricultural economics, (*b*) subject matter outside economics to facilitate research and reading in economics (examples are quantitative techniques and mathematics), (*c*) subject matter that provides an alternative view of phenomena considered by economists (the other social and behavioral sciences and the law should be included but to the extent the economist deals with biological and physical phenomena, these subjects may also be considered), and (*d*) subject matter that assists in putting economics, economic problems, and social phenomena in perspective in space, time, or concept (examples are geography, history, and philosophy). No one can have a comprehensive mastery of all these areas, but a case can be made that all professional workers should have an appreciation of each. Such an appreciation can be obtained in many ways other than by formal course work because subjects vary greatly as to whether they can be more efficiently tackled at the graduate level by course work or by individual study.

The following recommendations are made for strengthening graduate education in agricultural economics. First, greater reliance should be placed on problem solving and application of analytic techniques in workshops, seminars, and the presentation of individual research in reports and papers. Data collected during my tenure as graduate dean at Oregon State University demonstrate that agricultural economists tend to be in graduate school a shorter period of time than most disciplines (which is probably good) and spend a higher proportion of their time in coursework and less in research (which is probably not so good). One set of data that I have shows that Ph.D. chemistry students devoted 40% of their

time in graduate school to course work, but doctoral students in education and agricultural economics spent 81% and 70%, respectively.

Second, agricultural economics graduate education needs to be greatly strengthened in macroeconomics and economic policy generally. Few agricultural economists are at home with the macro concepts underlying monetary and fiscal policy, international trade, and economic development. Yet, as noted above, the source of many of the public policies and trends that influence the economics of agriculture lies in these forces.[3]

Third, agricultural economics graduate education is generally weak in areas (*c*) and (*d*) above. Graduate students in agricultural economics seldom are able to appreciate the approach of another discipline to the phenomenon of concern, and we are generally deficient in the perspective provided by geography, history, and philosophy. The remedy of these weaknesses poses a nice problem in resource allocation. How can we put such work into an already overcrowded graduate program? It is possible (and I have seen it done) to move in this direction by an appreciation of two facts: extensive coursework is unnecessary to obtain the viewpoint of another discipline (one or two courses or individual study with some direction can stimulate a lifetime of reading and growth) and the subdiscipline of agricultural economics does not warrant extensive series of courses in the subfields of marketing, management, finance, and resources. The emergence of the post-World War II literature reviews provides the graduate teacher and student with a marvelous opportunity (Martin). A serious student with some faculty guidance can obtain the essence of these subfields by pursuing these literature reviews with diligence.

Effectiveness of Incentives in Bringing about Desired Behavior

There has been considerable discussion in recent years about the impact of the academic incentive system on the way professionals use their talents (Heady). I focus on a different facet of this general problem.[4] Agricultural economics has been nurtured by the land grant universities and the USDA. On the positive side, this provided a clientele and a structure for activities and encouraged a truly superior tradition of service and application. On the negative side, it tended to separate us from the basic disciplines and the liberal arts. The current emphasis on accountability, usefulness, and relevance directs attention away from fundamental problems that arise in connection with applied work. Proposals for a competitive grant funding in agricultural and forestry research are an attempt to break away from the parochial nature of much work in the land grant universities and the USDA.

Part of the difficulty may result from the use of false or irrelevant dichotomies. An illustration is provided by Gordon's presidential address before the American Economic Association. The implication of the title "Rigor and Relevance in a Changing Institutional Setting" is that a choice needs to be made between rigor and relevance. A disservice is done by stating the issue this way. The most relevant problems are, by definition, difficult. To suggest that they are somewhat amenable to nonrigorous examination is illogical. To the extent that we succeed in promoting this kind of nonsense, neither the best minds nor the best methods will be attracted to applied problems.

The Capacity of Agricultural Economics to Respond to Change

Most public institutions have been subjected to numerous exogenous shocks during the past decade, and agricultural economics has not been excepted. As noted earlier, the subject matter of agricultural economics has changed significantly, but another and perhaps more fundamental change has occurred about which there has been relatively little comment. Two decades and even as recently as a single decade ago, the profession was dominated by the large agricultural economic departments of the Midwest. Today, there are departments located throughout the country that are contributing significantly in many different ways. Why has this occurred?

Since World War II, increased resources have been available to the profession even

[3] The work of Schuh on the effects of devaluation on agriculture is an example of the kind of research that needs to be emphasized.

The time has probably come when agricultural economics departments should cease hiring just agricultural economists. Only by confronting people who have in-depth education in the areas in which we are the most deficient are we likely to get the dimensions needed in our work. When these dimensions are reflected in our research, they will enter graduate training in a most significant way, rather than as just another course in economics. Even in departments where economics and agricultural economics are combined, this kind of integration still seems to be lacking.

[4] Neither do I discuss here the AAEA awards program as an incentive. My opposition to this program is on the record elsewhere (Castle 1970, 1973).

though the share of the federal agricultural budget to economics has been relatively stable. Furthermore, state appropriations have grown, and other sources of funds have developed. This has increased the pool of educated humanpower available because of the close relationship between research and graduate education.

Because of this expansion in humanpower, it has been possible even for the smaller departments to attract two, three, or more quite productive people who constituted the nucleus of the necessary critical mass to do outstanding professional work. Coupled with this has been the manifestation of many interesting social problems related to agriculture outside the Midwest. The rapid development of agriculture in the South and Southeast, the urbanization of the Northeast, and the resource problems of the West provide examples. Thus, there has been an increase in resources, humanpower, and new problems since World War II. It will be unfortunate if this should spawn a new orthodoxy. The variations in conditions and problems in the nation suggest that departments should be different. Dilution of quality will undoubtedly result if scarce resources are used to try to be equally strong in all of the many subfields that populate our subdiscipline.

The Ability to Generate Relevant Information

Two major concerns exist because appropriate information is not being generated, although the fault lies other than with agricultural economics. However, the capacity of agricultural economists for social analysis may make it possible to compensate for some of the inadequacies of the institutional framework within which the profession must operate.

First, agricultural economics is the major social science servicing agriculture. While there are a smattering of sociologists, anthropologists, and political scientists involved, only agricultural economists have the sustained nurture provided by substantial recurring funding. The trend toward competitive grants may assist the other social sciences attain comparable depth, but I do not believe it. Animal science does not depend on competitive grants for work in animal genetics, nor do we use competitive grants to develop depth in plant pathology. A comparison of the development of agricultural economics with other subdisciplines in economics that have not had recurring sustained support makes the same point.

In the long run, we should work for something approaching comparable support for our sister social sciences. Unless we do, we will continue to encounter technical solutions to the social problems of agriculture. In the short run, we should exercise self-discipline and not pretend that agricultural economics is capable of dealing with all social problems. Our modest success in analyzing the economics of organizations and rule making should make us humble about tackling even more complex problems. If the first part of this paper has validity, it is apparent that the scope of economics will be sorely tried. While I am not among those who are critical of the relevance of economics, I must also record my belief that it cannot be expected to encompass all social phenomena and problems.

Second, agricultural economics, as it is currently organized, is inadequate for the analysis of the macroeconomics of domestic and international agriculture. Farrell's paper details institutional inadequacies with respect to our capacity for policy analysis of the economics of agriculture, and there is no need to repeat these arguments here. However, I believe there are some supplemental comments that can be made.

At various times there has been strong work in agricultural economics at Harvard University, Vanderbilt University, Stanford University, and especially at the University of Chicago. Our subdiscipline would be very different if these efforts had not existed. While the states were properly concerned with state and local problems, these private university efforts provided us with overarching concepts and synthesized fragmentary studies (Jones).

As compared with the need, I see relatively little of this occurring on the international scene despite excellent work of people such as Mellor, Ruttan, and Schuh. Should the work in agricultural economics at the University of Chicago diminish and nothing comparable replace it, the situation will be even worse.

The institutional pressures are in the opposite direction. Agricultural economists are typically expected to do technical assistance within the developing countries. This usually involves education or research on problems as perceived and defined in the institutional complex of the country. Agricultural economists may also be expected to serve as a member

of a multidisciplinary team to develop new technology for particular locations. Yet I see little to resemble the scaffolding that Schultz provided for the economics of agriculture on the domestic scene. In view of the interdependence of nations and cultures and in view of the need for generalizing adaptations, the value of this kind of work is great. Unless this need is met, the danger is substantial that international agricultural economics will become increasingly fragmented. If this occurs, agricultural economists cannot expect to play the leadership role in international agriculture that they have in domestic agriculture.

Concluding Statement

Agricultural economics is currently being subjected to powerful competing forces. One set of forces are immediate and real and pull in the direction of great emphasis on the micro with short-run payoff in a narrow cost-effectiveness sense. But there are another set of forces in operation that suggest agriculture will no longer be the exclusive province of the land grant universities and the USDA. This set of forces denies the uniqueness of agriculture and stresses interdependencies within and between economies.

The institutional framework within which agricultural economics operates generally reflects well the first set of forces, and the profession has reflected these needs in its work. The institutional framework is less well suited to the needs stemming from the second set of forces.

The profession has little choice, indeed it has a responsibility, to be responsive to the first set of forces in its research and service. The existence of a significant graduate program, however, provides an opportunity for a better understanding of the second set of developments. If agricultural economists are to remain preeminent in the policy arena affecting agriculture, they must constantly reevaluate their graduate education. That which is happening in our graduate education today will have great impact on our professional performance a decade hence.

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Appendix

Criteria for the Evaluation of Institutions

Society has many institutions, which may be formal, informal, structured, nonstructured, for accomplishing social ends by influencing individual or group behavior. The objectives or ends are typically multiple in nature. Thus, judging the adequacy of an institution in achieving a single objective usually results in an incomplete evaluation.

The criteria suggested for the evaluation of institutions consist of five parts. Examples can be found of literature that bear on each criterion. However, at a minimum, all five considerations must be taken into account in judging performance. Further, no single body of literature can be relied upon for developing all of the above, and a heuristic approach is needed to utilize the theory that is available.[A.1]

(*a*) First is the adequacy of the institution in defining its domain of performance. This criterion is concerned with whether it is possible to know who is excluded, as the institution performs its role. An institution may fail because there is misunderstanding regarding who it serves. A small privately endowed, liberal arts college with highly selective admission criteria is less likely to be faulted for its failure to provide mass education than is a general purpose state college or university. Economic theory has something to contribute to the development of this criterion, although sociology and political science are useful as well. Externality theory is relevant to the boundary question, but, as has been noted, institutional statements about boundaries must do more than simply reflect physical conditions even though such realities must obviously be taken into account.

(*b*) Second is the precision of the institution in specifying the relation of decision making to the impact of those decisions. An institution needs to be specific with respect to who makes decisions and who bears the consequences of those decisions. The more democratic the system, the closer the correspondence between those making and those bearing the consequences of decisions. Regardless of the system of government, the situation is basically unstable unless the relationship is specified. The instability results from the always present prospect that the relationship will be discovered and made known but will not be to the liking of the populace generally (Dahl). Social psychology, political science, and economics all advance or accept the hypothesis that there is a relation between participation and behavior. The social choice literature on representation and appropriate jurisdiction is obviously relevant.

(*c*) Third is the effectiveness of the incentive system in bringing about desired behavior. Item (*a*) is neutral with respect to political norms; it pertains primarily to the degree of certainty that exists with respect to the sphere of operations. Item (*b*) permits one to relate the location of decision making to the impact of decision making, assuming the sphere of operation is known. Item (*c*) is more precise. The application of the criterion implies that social objectives can be discovered, that the relation of the two can be hypothesized and then tested. In practice, something less than ultimate social objectives may be pursued in order for the institution to be operational. When this happens, the institution may yield results that will not be consistent with more ultimate social objectives.

The neoclassical theory of economics is based on the normative assumption that the maximization of national income is desired. Conditions have been deduced that must exist if this is to occur. One such condition is that the incentive to incremental production reflects the social costs and returns of that production. The violation of this condition raises the presumption of market or institutional failure. Much of the recent literature on environmental economics has been concerned with the discovery and correction of such "failures" in economic activity. Such efforts demonstrate only that a single objective has not been optimized. More than this is needed to demonstrate that criterion (*c*) has not been met.

Fundamentally, of course, this item involves all of behavioral science. Even so, there is much important work that can be done on a quite pragmatic level. The work of Niskanen in demonstrating that, upon creation, the objectives of the bureaucracy become different than the objectives of the creators provides an illustration.

(*d*) Fourth is the capacity of the institution to respond to change. Many of the current questions about institutional performance stem from concern as to whether an institution has the capacity to respond to new information. In other words, does it permit social learning? New information can be accommodated in a variety of ways. Objectives may be adjusted, incentives may be changed, the domain of performance may be modified, or the demise of the institution may be anticipated (Dunn 1971).

(*e*) Last is the ability of the institution to generate relevant information. The making of decisions requires information. Institutions can provide for the generation of

[A.1] The economics profession has not been deficient, especially in recent years, in calling attention to the importance of institutions (Downs, Schultz, Shaffer). Further, there has been significant response to this need (Ciriacy-Wantrup 1956, Buchanan and Tullock, Olson, and Niskanen provide examples). Yet if the criteria suggested here have validity, the journey has not yet been completed.

information either explicitly or implicitly. The accuracy and relevance of the information that is generated has much to do with the quality of decisions that are made.

At this stage no one body of social theory can be utilized for the evaluation of social institutions. While I believe certain aspects of economic theory can be put to good use, it has obvious limitations. As noted, most or all institutions have multiple social roles. Because it is not possible to optimize more than one objective at a time, that part of the economic theory based on optimization may have limited value in institutional evaluations. Criterion (*d*) obviously pertains to nonstatic situations. While analyses based on static assumptions may have value, they cannot provide a definitive evaluation of institutions.

The AAEA—Issues and Answers

Paul W. Barkley, Charles E. Erickson, Bernard F. Stanton, Stephen C. Smith, and William W. Wood, Jr.

The American Agricultural Economics Association (AAEA) is a voluntary organization with about 4,000 members. The membership is extremely diverse. The only requirements for membership are an interest in agricultural economics and a membership fee of $25. The organization was formed in 1919 by a merger of the American Farm Management Association and the American Association of Agricultural Economists. As recently as the early 1960s, being an agricultural economist was equivalent to being a member of this Association. Since that time, the growing number of subspecialties and the increased remoteness of agricultural economists from agricultural policy has perhaps weakened the Association. Some observers feel that only about half of all practicing agricultural economists in this nation are members of the AAEA.

Recent AAEA presidents have made concerted efforts to increase the effectiveness of the Association so that all practicing agricultural economists will perceive some identifiable personal gain stemming from membership. These efforts have been thwarted by an amazing gulf that separates those who manage the Association from the dues-paying members.

The Association is managed by a volunteer, elected president and a volunteer Board consisting of six elected members, the immediate past-president, the president-elect, an appointed secretary-treasurer, and an appointed editor of the Association's journal (*American Journal of Agricultural Economics*). The Board is assisted by a number of standing and special committees. The lines of communication between the Board and the members are well defined but narrow; the linkages between the committees and the membership at large is very tenuous. Some committees operate with almost no input other than the experience and intuition of their own members. Other committees use extensive surveys to gather information and input.

The late 1970s will be a time of introspection and action for the Association. This session provided an opportunity for members to make an input into questions and ideas that maintain and run the Association. The session was conceived in 1976 at The Pennsylvania State University when President Farrell approached the Professional Activities Committee to ask if it would supervise a segment of the program during which members could raise questions and talk about their concerns for the Association.

Issue: Alternative Publications

The Association has been considering a publication outlet other than the *Journal* for some time. One possible alternative to the *Journal* is a newsletter that would carry information on meetings, semiprofessional activities, changes in employment, calendars of events, and the like. This newsletter could also include items that deal with contemporary economic issues and economic outlook information. Some organizations, the American Statistical Association, for example, have had something called *AmSTAT*, which does not look as if it would be very expensive to imitate. Can the AAEA publish this kind of document?

The Alternative Publications Committee has recommended that the materials that now appear in the back of each issue of the *Journal* be deleted and published separately as a newsletter. A recent survey indicated there was large support for this kind of separation and publication of the "soft" material. We do not at the moment know the exact cost of revising the Association's publication package in this way. There is also some concern regarding the ap-

This paper summarizes a session in which panel members responded to questions from the audience. The format of the paper is to state the issue and then characterize the answers given by the panel members. Paul W. Barkley was the panel moderator.

Paul W. Barkley is a professor of agricultural economics, Washington State University; Charles E. Erickson is with Cargill, Inc.; Bernard F. Stanton is a professor of agricultural economics, Cornell University; Stephen C. Smith is the associate dean of agriculture, University of Wisconsin; and William W. Wood, Jr., is an economist with the University of California, Riverside.

propriate contents for a newsletter. Should we take the material out of the existing *Journal,* or should we expand this material to include the dates and purposes of various meetings that may be of interest to agricultural economists? What kinds of information would be productive? These are important questions, and the Board or the Alternative Publications Committee would be interested in hearing from members about them. Many members have already participated in a mail survey related to this issue. By December 1977, the results of the survey and cost estimates for either a monthly, bimonthly, or quarterly newsletter will be available.

Issue: Service to Economists in Extension and Business

Agribusiness and extension economics are sometimes considered subsectors of the general profession. Since there are these recognized differences in areas of professional application, why is it thought to be more effective to target publication of the *Journal* to narrow interests of researchers rather than maintaining comprehensive treatment of the subject matter of economics and agricultural economics?

Annual meetings are sometimes divided into sections for special use by subgroups, but this kind of use should not negate the professional's basic interest in his profession: agricultural economics. The annual meetings should be a meeting of professionals, and it should reflect a high degree of professionalism. It should be useful to all agricultural economists whether they are employed by extension, research, resident teaching, or a private firm. The oft-cited division is an artificial one that has created more problems than it has solved.

The *Journal* raises similar problems. Some agricultural economists employed in extension have been critical of the *Journal* because it does not deal specifically with the problems they are investigating. Industry people have expressed a number of concerns about the professional publication. Although many members are concerned, it is likely that no two of them would agree about what should be done to improve the *Journal.* This disagreement is the real problem. It has been easy to be critical, but not so easy to make positive suggestions about improving things. The newsletter is the kind of thing that might attract some attention and solve some problems, but it can never be a perfect substitute for the *Journal.*

Issue: The *Journal*'s Clientele

Members of the AAEA may be making a mistake when they attempt to differentiate various clienteles for the professional journal. The real concern is how the *Journal* can provide a means for professional development. It should help readers understand and interpret the things that are at the cutting edge of agricultural economics. It should deal with the issues that are of major concern among agricultural economists. The *Journal* can be very important in terms of professional development. Comparisons are not always apt, but perhaps we can learn a great deal from the *American Economic Review.* It provides access to some of the current and more important economic thought—much more, perhaps, than the *Journal.* Can the *Journal* provide more material related to professional development?

All AAEA members should go back and reread Farrell's presidential address to learn the general change in orientation of materials that come out of this professional association. There have been significant changes in the sort of material that is taught and is in research programs. There is a great deal more "relevance" to the profession now as opposed to a decade ago. This increased breadth and relevance is beginning to show in the programs of the annual meeting and the *Journal.*

Issue: Membership in CAST

The Council on Agricultural Science and Technology (CAST) was established in 1973. Since then, the AAEA has been asked continually to join CAST and to assist in preparing reports for use by the Congress and by citizen groups. Many individual agricultural economists have served on CAST committees and task forces, but to date the AAEA has not participated as a sponsoring group. Why not?

In 1974–75, the Association appointed a committee to prepare a recommendation regarding the AAEA's potential membership in CAST. The three-member committee submitted a lengthy report that included arguments for and against membership. The same argu-

ments still apply so it can be assumed that the issue of membership in CAST is still controversial. (The committee report appears in the December 1975 *Journal.*) The Board tried to reflect the desires of members when it voted not to become a member of CAST. The Board and the membership perceived CAST to be an organization that takes political positions. Such positions are expressly forbidden by the AAEA's Constitution. Individual agricultural economists can and should continue to participate in preparing the reports issued by CAST, but that is a different issue than whether or not the Association should become an active member.

The nature and public posture of CAST may be changing, and it undoubtedly is a matter that should be monitored. Agricultural economists have had a great deal to do with changing the nature of some of CAST's positions. The Association has always cooperated in supplying people for task forces. Before the Association reconsiders joining, however, someone must study CAST's bylaws very carefully to learn the stated objectives of the organization, the composition of its executive Board, and the way in which decisions are made by that Board. The AAEA may have a greater influence on CAST by maintaining its stance outside the organization. Sometimes an outsider can have more influence than an insider.

Issue: Midwestern Dominance of the AAEA

The AAEA sometimes appears to be dominated by those agricultural economists working in the Midwest. One way to help open the Association to others would be to have the regional associations elect members to the Board of Directors. Another way is to have economists from extension and from industry play a more prominent role in managing the Association.

The Board of Directors has inquired into the question of regional representation on the Board. The majority decision, almost always a unanimous decision, is that we want a national association, not a federation of regional associations. To allow for regional differences, however, the presidents of the regional associations are asked to serve as ex officio members of the AAEA Board.

The issue centering on participation in the AAEA is more difficult. Hildreth's presidential address mentioned making the Association more open, but the openness must come through individual members becoming more assertive and more willing to take responsibility. Regardless of their place or type of employment, agricultural economists must be professional and must take the initiative in asserting that professionalism. This requires a commitment of time and energy, and often the individual member must take the first step in order to be recognized by the leadership of the Association. It is almost impossible to name an instance in which a recent president has refused an offer of assistance.

Issue: Participation in the Annual Program

The annual program appears to be dominated by people from land grant universities and the USDA. They seem to talk, moreover, about academic themes. Those agricultural economists employed by industries cannot find places on the program or even useful sessions to attend.

Industry economists have consistently complained about the Association. The *Journal* was at the top of the list for many years. More recently, there have been numerous complaints about the program. However, if industry economists have a complaint about this year's program, they should look to themselves. All members, including industry economists, could have submitted an "organized symposium."

The most persistent complaint among agricultural economists in industry is simply: "Why should I join?" If you cannot find an affirmative answer to that question, obviously it is unwise to join. Many have never had any difficulty deciding that membership has a positive payoff. Those who continue to doubt the value of joining should know that the Association is increasingly open to industry problems and industry participation. One caution is in order. In the past, industry economists have been heard largely because they opened their mouths. If they do not speak up, they will not be heard.

The Association seems to be made up of individuals with very selective skills. How can the Association arrange for meetings of agricultural economists who have such high degrees of specialization?

There are three ways. First, the president can arrange invited papers sections to accom-

modate the needs of a specialty. Second, the specialty group can develop a contributed papers session, or if the practice is continued, an organized symposium. Finally, the specialty group can ask the Association to sponsor a special meeting. This last alternative is possible under a policy adopted by the Board in January 1977. Under any of these plans the specialty group must take the initiative.

Issue: Membership Growth

The AAEA does not seem to grow as rapidly as degree conferrals and employment opportunities indicate it should. Many individuals and institutions are not joining.

As in so many cases, the answer to this problem lies in individual reaction. The Association has no mechanism to learn of potential members. Individuals who are already members must act as recruitment agencies for the group. Chairmen of academic departments and leaders of units in the USDA have often been asked to recruit from within their own units and have been very cooperative.

Recruiting in industry is more tedious. Industries must be aware constantly of the antitrust considerations that make it difficult for people in the same industry to talk to one another. Nonetheless, there are many individuals who should be contacted and asked to join.

The institutional membership is a related issue. The Association has not perfected means of gaining and maintaining the sponsorship of institutional members. It is possible that as many as 500 firms could be attracted into the organization to serve as institutional members or sponsors. Some agricultural economists now employed by industries are attempting to compile lists of firms that might become targets for institutional recruiting.

Closing Comment

In closing, we would like to recall Hildreth's presidential address, which mentioned and discussed many of the issues and themes that have come up in this session. It is good to hear someone who cares about the Association with that degree of intensity. By participating in this discussion, members, too, have indicated their care about the Association. We hope that care continues, and we hope that future presidents, future committee chairmen, and future program chairmen will find opportunities for members and others who are active agricultural economists to become active in this Association and to make the Association the important vehicle that it can be.

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Potential of Research on World Food and Nutrition Problems

Charles E. French

This paper draws on two years of experience with the World Food and Nutrition Study (WFNS) of the National Academy of Sciences. I give some background about that study, but my comments are not restricted to it. Primarily, I define a professional issue, namely, that our profession lacks a meaningful and exciting research agenda for tackling world food and nutrition problems. Moreover, we are failing effectively to communicate both our skills and our needs. I am not discussing a new topic, e.g., Farrell provided a scholarly paper on many of these issues. Certainly the fellow's lecture by Kelso (this issue) will be a classic in our literature. My contribution lies especially in the chance to discuss a case study that involved substantial input from our profession.

The World Food and Nutrition Study

President Ford requested the WFNS study in December 1974 following the World Food Conference in Rome. He asked the National Academy of Sciences to assist. The issue specifically focused on how the U.S. scientific community could give leadership.

The Academy interacted with about 1,500 of the outstanding food, nutrition, and related scientists in the United States and throughout the world. The study was organized around twelve teams of experts covering the various subject matter areas; two "blue sky" teams to look at the unusual possibilities (one primarily of physical sciences emphasized supply and one primarily of social sciences emphasized consumption); one team to look at organizational changes; and one overall team to exercise some priority assessment of the research proposals of the other teams. The teams had both general and applied scientists. Two hundred and one people served directly on the study teams with eighty of those being social scientists, predominantly agricultural economists. The social scientists were diffused throughout the teams. Often they were limited to specific subject matter. To some extent, they may have been taken for granted and probably were not given as much attention as the others. This was particularly true with regard to defining their own specialized areas of research. A steering committee, several of whom were social scientists, gave overall supervision to the study. The dominant professional background of the staff was social science.

The team members were asked detailed versions of three questions. First, they were asked to delineate areas of research that their talents could address to alleviate constraints on availability of food and nutrition worldwide. The idea was to tackle both frontiers of science—external and internal (Weisskopf). They were to avoid presenting a shopping list but rather selected priorities that were head and shoulders above others they might list. Second, they were asked to evaluate the effects expected from this research, particularly in giving U.S. leadership to aid in solving the global problem (Arndt and Ruttan). Third, they were asked to lay out the institutional, financial, and policy considerations relevant in getting the job done. They were not constrained by resource limitations, but they were expected to justify their choices. Most teams came up with a rather short, substantiated, and well-defined list of priorities.

The study has resulted in two reports prepared by the steering committee—an interim report (National Academy of Science 1975b), accompanied by a special National Academy of Science study (1975a) on U.S. research pri-

Invited address

Charles E. French is with the National Research Council, National Academy of Science, Washington, D.C.

The author especially would like to acknowledge the ideas and support from colleagues on the staff and study teams of the World Food and Nutrition Study. Charles E. Hanrahan and Emery N. Castle gave helpful reviews of an early draft of this paper. Yet, in no way does this paper purport to represent them or the findings of the WFNS per se.

orities, to President Ford and a recent final report to President Carter (National Academy of Science 1977). These are being followed by five more volumes containing the specific reports to the steering committee by individual teams, including a social science volume. The two reports to the White House have been made public; the others will be soon.

Let me make two, probably unnecessary, caveats. These refer to an editorial technique that I will use but would avoid if I knew how. That technique involves comparison of social scientists with their counterparts. First, no attempt is made to downgrade social scientists; they compare favorably by traditional peer evaluation techniques regarding knowledge of subject matter and method. Second, no attempt is made to show disappointment with any social scientists who worked on the teams; they represented their disciplines effectively and accurately. All comparisons are made to suggest tangible things from other disciplines that agricultural economists might observe and possibly emulate. Suggestions for improving our discipline do not deal primarily with professional stature; they deal mainly with the modus operandi by which we can more effectively help tackle the global problems of hunger and malnutrition.[1]

Urgency in Research

The age of complacency for our profession is gone. We talk about professional direction at every AAEA meeting. For the most part we come out saying, "Tomorrow we must get organized!"[2] That is not good for morale. Compared with other scientists in the WFNS, agricultural economists lacked pride and scientific camaraderie, our frustration level was higher, and our satisfaction level lower.

Our potential emphasizes the urgency. The scientific community in general has been subjected to a catharsis. Scarcity, human rights, social justice, and challenges to the scientific method have laid clean some broad opportunities for research. The problems are complicated. But we have a comparative advantage for many of them. We are dealing with interscience, interpolitics, and international issues, particularly involving resources, food, and policy making. Farrell says it is "increasingly difficult—if not impossible—to analyze and understand agriculture and related public policies except as an integral part of national and world economic, social, and political systems" (p. 786). Warley indicates the point forcefully saying, "now foreign economic policy is the core of foreign policy" (p. 820).

A profound and effective paper by Castle has done much to stimulate me both by its forthright evaluation of our past contributions and by its definition of an important new direction. I listen when he concludes on the realities of adapting to technological change as follows: "Obviously, social adaptations are needed on a global basis to these realities. Social adaptations and social control mechanisms are needed to cause individual behavior to be consistent with social objectives. These mechanisms have been modified indirectly by natural science through the widespread adaptation of technology and they have occurred as a result of social experimentation and learning, stemming from technical change. They have not been changed to any significant extent, I believe, because of knowledge advance in the social and behavioral sciences although Adam Smith, Karl Marx, and J. M. Keynes might be cited to the contrary" (p. 8).

Such is his dire evaluation. But as usual Castle does not leave us there. He goes on to offer some new direction:

> Let us assume that the research succeeds in doing what the scientists say it holds the prospect for doing. . . . The question then becomes—how will this be viewed by the millions around the world who make the crucial decisions on family size, education, human health, production, harvesting, and distribution? Will it be viewed as a permanent expansion of the opportunity for even greater populations and even greater consumption of material 'things'? Or, will the increased output carry with it appropriate incentives for future adjustments? . . .
>
> A major re-orientation of research, primarily but not exclusively, social and behavioral in nature, is recommended. Such a re-orientation need not be highly expensive, as compared to natural science research efforts. . . .
>
> At the present time much of the social and behavioral science research and technical assistance is of a narrow scope on production and problems within the developing countries.
>
> . . . wants, desires, and hence, consumption, are largely 'givens' rather than variables to be explained

[1] Among the job specifications assigned me in the WFNS was staff responsibility for the economic input. This acknowledgment should make clear the ultimate responsibility for any concerns about such input.

[2] This overstatement, of course, is unfair to many fine papers given at this meeting in prior years, especially the papers by Farrell, Soth, Schuh, Barkley, and Warley.

in many social science investigations. This needs to change (pp. 7–15).

A sociologist, Philip Olson, recently gave a paper in which he surveyed recent sociology literature emphasizing these same ideas.

The Current Situation

Food and nutrition are much in the limelight. Energy is the spectre of weakness of the commercial world, but hunger is the spectre of the poor, and that is most of the world (International Food Policy Research Institute). U.S. policy has put food to the front starting especially with the China-Russian compromises. Terms of trade and population trends portend an emphasis on food. This is not so much to say that hunger and malnutrition are more urgent than in the past. The difference lies in the fact that, for the first time in history, we have a good chance to do something about hunger and malnutrition, and both the third world and we know that. Warley speaks of the "success of the developing countries in shifting the subject of their poverty from the periphery of world affairs to the center" (p. 825). Also, the newer emphasis on the adverse effects of poor diets on health have added concern (U.S. Congress).

A cohesiveness of concern about food problems has evolved worldwide. We all know about the Rome World Food Conference of 1974 and the follow-up conferences. Most major countries have programs of research and assistance (Cordaro). In the WFNS, we found sincere concern and evolving commitment worldwide to do something about this problem. This ebbs and flows, but it has solidified and has a permanence.

The basic conclusion of the WFNS was one of scientific and technological optimism. The consensus of the scientists was that they could meet the challenge laid out by President Ford if other members of society handled their part effectively. They particularly were concerned that the political and social problems be handled; otherwise, they laid no bets on the chances of success. Wharton also held that this was his view.

Probably the most innovative and substantive contribution of the WFNS was the couching of this problem in much broader terms than usual. The study discusses the political will of the poorer countries, joint programs with scientists worldwide, and social science research with special emphasis on poverty and the myriad of debilitating effects that poverty and hunger have on people. This is much more than the second-, third-, and fourth-generation problems of technical advance. This broader orientation does nothing to play down the importance of technology. It merely reorients it in a broader formulation. The press has emphasized this difference, and the reaction has been favorable. It is consistent with the current mood. President Carter in his special address worldwide on inauguration day highlighted hunger and poverty in his human rights pledge (Overseas Development Council).

In the WFNS, the need for priority assessment in research came through clearly. The public is tired of hearing scientists merely asking for more money. They want convincing arguments from scientists as to what taxpayers can expect if resources are given to the scientists. This study probably consolidated the largest consensus judgment ever by scientists to justify their existence. But methodologically, the scientists demonstrated time and time again that, unless one disciplines them and forces priorities, they simply will not make these choices.

A healthy respect was demonstrated for agricultural research by the general scientists and policy makers. Also, a healthy optimism about the contributions to be made by social scientists was evident. This was optimism as contrasted with outright respect. Most general scientists did not doubt that social scientists could do the job. The applied coworkers (primarily from the USDA-land grant complex) of the social scientists were doubtful but mainly supportive. The attitude was basically one of "wait and see."

The Academy report recommended 20% increase in real terms immediately and 10% per year increase the next four years. Several factors add strength and momentum for food and nutrition research. General scientists can get research funds out of the broad public concern budgets, e.g., space, health, energy, and environment. They will do so, often by incorporating the food and hunger problem into their research proposals. The agricultural scientists have gained respect (e.g., for the upgrading of personnel and for the way scientific knowledge has helped farmers handle the corn blight problem, to adjust to recent weather changes, and to make an important impact on foreign trade and the level of food prices). Science

maturity in this country is recognized. An important scientific international network is evolving, from the international centers to a growing community of science.

The role of the universities in research may well increase. The Title XII Program formalizes the potential in the world food and nutrition areas, but the story is broader. The universities need the money, and research funds are probably their most attractive potential source for increases. Also, some evidence shows that the private sector emphasis on research may be declining; the public may need to pick up that slack.

Having said all this, the case put forth for social science research in the research in the WFNS was not exciting to the other scientists, the staff, and the steering committee (table 1). The proposed research on national food policies and organizations gave the impression of a massive, and possibly an impossible, undertaking. The need and importance of it were accepted, but counterpart scientists expressed concern about its acceptance by the policy makers and openly admitted failure to understand what was to be done. They understood the trade policy research better, and the food reserve research was well received.

The management work had support but mainly as service to a host of other people. This was true of the benefit-cost work as well. Moreover, the benefit-cost work was often thought of as something to be done *ex post facto*. The work on information systems was an exception—the proposed information management work was substantive; also, that interdisciplinary report itself was strong. (I did not include it in table 1 as being specifically social science in orientation.) The marketing and food science work did not impress many as being scientific or important and mainly was considered only as an extension of production.

The nutrition policy makers expressed interest in the social science input, but they viewed a rather narrow range of social scientists as being helpful.

The foregoing may be unnecessarily pessimistic. It may put too much emphasis on the attitude of the counterpart scientists, the staff, and the steering committee as proxies for the scientific community and the policy makers. Yet one has to be honest; the agenda failed to impress these groups relative to the support they gave other areas.

The social science proposals put forth were from several sources. The study team reports usually were from teams that had two social scientists among possibly a dozen or more counterpart scientists. Several teams were predominantly social scientists, but often their work was circumscribed, e.g., to research needs on methodology, trade, information systems, or food availability. Various conferences on social science input were held with public and private groups and individuals. Much staff and steering committee effort was devoted to the subject. The basic problem was not that we did not have good ideas and many of them. The problem was lack of a well-defined, finite set of priorities that were understood by, and excited, others.

Professional Implications

The study design and organization may well have put the social scientists at a disadvantage. Yet, concern about professional orientation is not limited to this study or to me. Thus, what can we learn?

Six things about the posture of social scientists stand out. All six made the job of the social scientists in the WFNS more difficult.

First, their professional opinions were more varied than those of their counterparts. They spent much more time arguing among themselves, particularly with regard to what constituted their most important research opportunities. They had more difficulty in compromising for their common good. Interestingly, the most outspoken critics of the social science input were other social scientists. This was not generally true in the other fields. Diversity of thought is a cornerstone for scientific goals and objectivity but can be overdone. We may have outgrown the need to "discuss" everything to death. For example, several of us have long thought the inordinate use of discussants at AAEA meetings is an anachronism.

Second, the scope of the subject matter, and probably method, spanned by social scientists was wider than that of their counterparts. The other scientists were thrown off guard by the lack of specialization of the social scientists and the quickness with which the social scientists would claim their proficiency and the feasibility to research so many areas. The fact is that our study asked specifically for priority recommendations, the best foot forward, of the social scientists. Relatively, this came

Table 1. Recommended Social Science Research Priorities, World Food and Nutrition Study

Priority Area	Nature of Research Effort	Major Effects	Sources of Support[a]
Policies and organizations			
National food policies and organizations	Improve policies and organizations affecting food production, distribution, and nutrition in developing countries: (*a*) human performance in food systems; (*b*) comparative studies to identify transferable improvement factors (decentralization, local participation, staff development); (*c*) interactions of income distribution with food production and nutrition; (*d*) methodology of sector analysis	Early results in improving effectiveness of policies and organizations relating to food systems and orienting selection and implementation of other biological and physical research; give farmers incentives for production and provide prices that will give more effective distribution	AID, NSF, USDA
Trade policy	Improve effects of trade policy on food production and nutrition: (*a*) studies on effects of trade liberalization; (*b*) consequences of international management of trade; (*c*) optimum trading patterns	Early effects on orientating country food policies for balance between own production and reliance on trade; improve diets, incomes, and national economic performance	USDA, AID, DOS, DOC
Food reserves	Improve role of reserves in relation to other measures for stabilizing food supplies: (*a*) improving developing country food reserve practices; (*b*) identifying improved mixes of reserves and other measures to stabilize food supply	Relieve hunger and malnutrition due to production instability	AID, USDA
Management			
Farm production systems	Improve production systems, particularly for small farms in developing countries: (*a*) methodology for identifying appropriate farming systems; (*b*) multiple cropping; (*c*) soil and water management; (*d*) equipment-labor relationships	Realize potential for two to four times present production in humid tropics; more modest increases in semiarid tropics	AID, USDA, EPA, ERDA
Management services to other groups	Improve the functioning of technical areas by giving management services: (*a*) pest management (*b*) tropical soils (*c*) water and irrigation (*d*) aquatic systems (*e*) weather and climate variation (*f*) information systems (*g*) food losses	Much more efficient use of resources in many other special areas and when interdisciplinary effort is needed	AID, USDA, NASA
Benefit-cost analysis	Assess the expected returns from other programs: (*a*) chemical fertilizers (*b*) animal diseases	Orientation of programs of research and use for these two areas	AID, TVA, USDA, NSF
Marketing			
Market expansion	Extend market scope for consumers and farmers in developing countries:	Stimulate production and consumption and cut food losses	AID, USDA

Table 1, cont.

Priority Area	Nature of Research Effort	Major Effects	Sources of Support[a]
	(*a*) enhancing purchasing power; (*b*) transportation; (*c*) marketing institutions; (*d*) managing marketing flows of major commodities		
Nutrition Policies affecting nutrition	Improve effects of full range of government policies: (*a*) effects on nutrition of policies and practices usually formulated with no consideration of possible nutritional consequences	Nutritional improvement in short run; in long run dietary changes may benefit health and life expectancy of large population segments in United States and developing countries	NIH, NSF, USDA, AID

Source: National Academy of Science 1977.
[a] AID is Agency for International Development; DOC is Department of Commerce; DOS is Department of State; EPA is Environmental Protection Agency; ERDA is Energy Research and Development Administration; NIH is National Institute of Health; NSF is National Science Foundation; TVA is Tennessee Valley Authority; USDA is U.S. Department of Agriculture.

much harder for the social scientists than it did for their counterparts.

Third, the social scientists are understaffed and poorly resourced. The other scientists often asked whether or not the social scientists had a "critical mass." The counterpart scientists were serious in saying what they could do, but they were just as serious in saying what it would cost and how many more scientists would need to be trained if society expected them to do the job. The social scientists seemed to be willing to take on things much more quickly, and dollar and manpower costs were often an afterthought.

Fourth, social scientists do not delineate well between their service role and their specialty competence. Their versatility causes confusion about the role that is expected of them by both other scientists and policy makers. Also, it probably relaxes the priority assessment pressure on them when they are deciding what they can do specifically on their own. Social scientists have a pride about their interdisciplinary competence. The WFNS organization put emphasis on interdisciplinary work; this made it difficult for the specialized competence areas to evolve. The problem is inherent in our profession. The service demands are immense, and they are competitive with other things. We must do something to delineate the service role, decide how we can handle it, and articulate our professional policy about it to others. Confusion on this point clouds our respectability. Johnson has proposed a troika of problem-solving research, subject matter research, and disciplinary research. This is a start. Our key social science study team sorted their recommendations along this line, but it has not sold too well. But this notion deserves consideration.

Fifth, social scientists were more resistant than their counterparts in trying to estimate the impacts of their work. This may have been a more difficult role for them, or they may be more knowledgeable about the pitfalls in such activities. But the WFNS is unique in the degree to which scientists did attempt to justify their existence. So far, policy makers and funding agencies are impressed with this aspect.

Sixth, social scientists had more trouble communicating with their counterparts than the others did among themselves. This probably could have been expected. But it caused at least two problems. It tended to be used as an excuse for not ironing out mutual scientific notions between social scientists and the others. Also, it resulted in the burden of communication being placed upon the social scientists. The counterpart scientists had the social scientists on the defensive, e.g., they would ask, "how do you research an institution—anyway, what is an institution—a farm, a court of law, a family, a marriage?" By then the social scientist was frustrated, if not mute.

Thus, we are too opinionated, too broad, too poor, too overworked by others, too cautious, and too hard to understand! In addition, there were times when I thought the agricultural economists must be professional orphans. The family disciplines for most counterpart scientists were the bases for their un-

derpinning and often the stimulants for their pragmatism. Kelso demonstrated how essential this is. This problem came to me many times when counterpart scientists asked me or other social scientists what we considered to be our basic research needs, and so many times we mumbled a nonanswer. I wonder if the general economics profession is pushing us hard enough, but that is the basis for another paper.

The Opportunity

The time has now come for someone to lay out the research agenda. So, I will list eight areas. Unfortunately (or fortunately), their discussion must be brief.

This list may verify my own inability to avoid the generic dilemma—so many exciting things for us to do and so little willpower to say "no!" But the list attempts to use the experience of the last two years; the thought, work, and frustration of my many colleagues who struggled with this subject; the broad picture of what other scientists are doing; my inability to explain my professional colleagues to many others who wanted to support us; and my attempt to select research that could be additive and hopefully holistic.

Allow me to return a moment to Castle's new direction. He said:

"Examples of the kind of research issues I believe should be on the agenda for high priority examination are: a. Investigations which will lead to a better understanding of population growth under a variety of conditions. . . . b. Comparative analysis among nations and states of adjustments to particular resource endowments. . . . c. Investigations which will lead to better understanding of the compatibility of systems and organizations with the objectives of the larger society. . . .

"These investigations will have the following characteristics: 1. They are concerned with social control mechanisms. . . . 2. They will be concerned with the linkage and the flow of information between large systems and individual decision makers. . . . 3. They will constitute a significant change in perspective. . . . they will tend to concentrate on the determinants of consumption over time . . ." (Castle, pp. 12–15).

Resource economists are making important contributions to the formulation of this type of problem. Kelso has now given us an exciting personal testimony that intellect, insight, hard work, and great patience actually can integrate a piece of our integrative science. The trick is to avoid Boulding's devil of suboptimization—a theme that my management research has twisted in my gut much as Kelso's land economics twisted it in his.

Meaningful problems in food and nutrition characteristically are broad. Optimization equipment is difficult to construct. Too often an important part of the problem is assumed away to fixed constraints; we did this with early linear programming formulations involving the divisibility problem on fixed costs. The paradox of optimization lies in its increasing power as the problem is expanded. This is the thrill that motivates the large model optimizer.

Kelso and Castle scare me as they expand our definition of consumption in such problem formulations. This becomes especially troublesome in world food and nutrition research with its geographic and time-dimension variations. But I am convinced that we must try. We may need the leavening effect of some of the notions of Lindblom's "muddling through," but we do have a chance of surrounding these massive problems.

Now for my list of eight.

People around the world need help on policy evaluation. We have techniques and tools, such as sector analysis, for such evaluations. Also, we have some understanding of policy implications, part of which might help others, especially on policy dealing with technology. Policy evaluation is an area of strength. In policy evaluation research itself, we need more work on food reserves. We might do some method work on the potential of business management planning techniques as a way to assist developing country governments to avoid policy by crises. Many other possibilities exist. The areas outlined in table 1 are researchable.

Trade is essential if we are to avoid the temptations so attractive to technologists and others to make every country self-sufficient. Interregional trade research within countries and among groups of closely aligned countries is a need. The appropriate emphasis on self-sufficiency is a major problem. The profession has delineated the trade problems effectively, and judgments are reflected in the WFNS. But overall we are not staffed and organized well to do an outstanding job on trade. Some good

trade work is being done, but we need critical masses at more institutions and more collaborative work with analysts abroad, including emphasis on our traditional markets as well as developing competition (Krause).

Global models for coordination of production and consumption decisions are needed. These are more than current world models. We assessed the world model work in selecting the methodology for the WFNS. These models must be strengthened greatly if they are to do the job. Such research also may give the profession an opportunity to do more with the theory of holism. Currently, scientists use it as a buzz word to replace "scenario," which we have run into the ground. As I understand holism, the theory does not merely state that synergism gives a total greater than the sum of the parts. It also contends that a holistic component is identifiable in and of itself and should be the focus of the conceptual notions. Statisticians did more when they decided to look at the error term for what it was than they did when they handled it as a nuisance. Possibly we have another handle for big problems. The thrust of the world modeling effort is certainly not in our professional hands. If we are to do much about that, we have much work ahead of us.[3]

Research on institutions and their place in development was much discussed in the WFNS. The need for such research is dramatized by a crucial decision in the WFNS. It concluded that current knowledge was inadequate to design a food and nutrition institutional arrangement that would assure a high priority research agenda. So we were forced primarily to tackle the agenda itself. Some think that the WFNS approach was frivolous, but we considered it the best alternative.[4] A growing body of literature on institutional analysis has evolved. But we do not have a solid social science institutional research thrust, and a dire need for it exists.[5]

Farm management may be in for rebirth. Many questions asked in the WFNS had to do with some of the simple concepts of farm management and where farm management fits in the total development process. A serious adaptation will be needed to improve our knowledge about economies of scale, especially for the small farm in the myriad of settings in which it is found worldwide. The WFNS makes a strong assumption, along with many other studies, that we must get world production up substantially through smaller farms. It may be sacrilegious, but I hold that social scientists have significant responsibility to test that hypothesis. The emphasis on small farm development in the centrally planned countries is a special problem of note (Lazar). Hopefully, the farm research can be coordinated with needed research on household economies.

Technology diffusion research has had some inputs from this profession, but mostly it has been done by sociologists. Also, my impression is that the amount going on currently is nominal. Probably the most asked question in the WFNS was whether or not social scientists could explain why we were not getting more adoption of science and technology findings. Some in-house assessment of the value of social science research generally might be quite important and cathartic.

Marketing and business management research will be needed for improved world food and nutrition and is probably already overdue. The research in this area relevant to developing country problems was not impressive. Work at Michigan State University and Harvard University is encouraging but inadequate. The private sector work gave signs of declining, and it is too sketchy to be a major factor. Research on the role of the market as a link between commercial systems and agrarian development is recommended.

The poverty problem, as viewed by many including the Steering Committee of the WFNS, is nearly an identity with the world food and nutrition problem. Problems of the poor are obviously intertwined with the problems of hunger. Will social scientists do much about this problem? Our track record on poverty has been miserable in our own country and in our profession. We should make a decision as to whether we want to gear up for this worldwide. If we do not register a disclaimer,

[3] At least one recent analysis holds that we should be more involved in the world modeling effort as it is now evolving, such as at the International Institute for Applied Systems Analysis in Austria.

[4] We did make important organizational recommendations in the WFNS, but at best we compromised and worked on both organizational and subject matter priorities. I have elected specifically to avoid discussion of the organizational recommendations. (I am pleased that they are discussed elsewhere in the 1977 AAEA meeting.) Another proposal was that we wait and have the social scientists make the priority assessment, but we thought urgency foreclosed that possibility.

[5] See the forthcoming report of study team 7 of the WFNS where one classification for institutional research is proposed.

we will be held responsible for research in the area.

Conclusion

The WFNS adds support to a strong public and scientific expectation for social science research. Agricultural economics can lead the way for this research on world food and nutrition problems. The profession has the potential, especially in its own scientific personnel and in external support. Ironically, the biggest problems of the profession currently are in applying its own expertise in better managing its own profession. But doctors' wives die young, and psychiatrists' kids are often truants or delinquents!

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Discussion: Research Needed to Increase Food Production

R. H. Wellman

As the World Food and Nutrition Study (WFNS) points out, the United States must increase its support of certain high priority research areas now if the people of the world are to be free from hunger in the year 2000. With adequate support and selection of priorities, it is almost a certainty that the people can be fed. In the areas of crop and animal production, insect control, and aquatic food sources alone, the study teams appointed by the National Academy of Sciences have identified seven high priority areas, which if pursued vigorously could easily double or triple the world's food supply within the next twenty-five years.

These areas are integrated pest management, nitrogen fixation by soil microorganisms, increasing photosynthetic rates, genetic manipulation, breeding resistance of plants to such stresses as drought and acidic soils, increasing livestock carrying capacity of grazing lands, controlling diseases such as sleeping sickness or East Coast Fever in livestock, and reducing the waste in fish processing. They offer major new pathways for the increase in food supplies. If research proved successful in the areas listed above, and if research findings were translated into farming practices in the developing countries, the food supply could essentially be doubled again by the year 2000 as it was in the developing countries between 1950 and 1975. This earlier doubling, the only gain of its magnitude in history, resulted primarily from increased use of fertilizers and pesticides and from traditional plant breeding.

It may be instructive as an example to describe in more detail the research proposed for one of these major areas, that of plant stress. Until now most efforts to overcome the effects of plant stress have been to supply the missing ingredient if it were in short supply or to avoid it if it were in long supply. This means irrigation where lack of water causes plant stress and not using land where acidity makes aluminum toxicity a serious problem. The world must get an increasing portion of its food from problem soils and from areas that have been considered too hot, too cold, or too arid for crop production. It is customarily the poorest farmer that has the worst land and the least chance of irrigation. He also has the problem of having no reserve resources. He must raise a crop every year in order to eat; yet the lack of an adequate monsoon may make his potentially high yielding strain shrink and produce no grain.

There are seven fields of research proposed to lessen the effects of plant stress in food crops: (*a*) developing rapid screening methods to determine resistance of cultivars to various stresses; (*b*) incorporating resistance to aluminum toxicity and other stresses into high yielding varieties of crop plants; (*c*) breeding crops for a shorter growing season to avoid drought or frost; (*d*) breeding for wider and deeper root penetration so that the cultivar can make maximum use of the scarce water or mineral nutrition; (*e*) improving the symbiotic relationship between soil fungi and plant—in the case of mycorrhizal association, the resultant complex functions as if the plant had a larger root system; (*f*) breeding for higher resistance to salinity—plants with good resistance could withstand the use of brackish water for irrigation; and (*g*) modifying farming methods so that stress is prevented or reduced (for example, shading of a lower crop by a taller one). While these problems can be solved only if some very fundamental work is done, the approach to all of them is mission oriented (i.e., if successful, more food will be produced).

The WFNS has made a great contribution toward setting the priorities of research. At Boyce Thompson Institute we have reordered research to put maximum efforts on three of the priority research areas recommended by the WFNS: biological nitrogen fixation, plant

R. H. Wellman is the director of the Boyce Thompson Institute, Yonkers, New York.

stress, and integrated pest management. We have also established interdisciplinary collaboration between ourselves and other interested parties, such as Cornell University and the International Rice Research Institute. All of us believe that the most important and exciting work we can do is to help solve the food problems of the future.

I have been somewhat surprised that the social scientists appear not to have participated in the studies leading to the recommendations of the WFNS to the extent that the biological scientists have. I say this in spite of the very valuable contributions made to the study team I chaired by two of your distinguished colleagues, McPherson and White, and, of course, French was also most helpful. But it seems that the agricultural economists should be leading the effort to quantify the importance of various research approaches. All together, twenty-two research areas have been defined in the WFNS report, and all have been given equal importance. No one has said which crops, in which countries, are most important. If the biologists attempt to cover all the problems in these recommendations, they will spread themselves too thin. Cannot agricultural economists point out the bull's-eye and let the biologists shoot at it? Were agricultural economists to undertake such a project, they probably would need all the quantitative skills they have. Finally, as biologists approach success in making the plants perform as they should, could agricultural economists tell them, and more importantly the farmer, what their efforts are worth? Do agricultural economists need to develop any new analytical tools to help when the time comes?

At the very least, it seems that in this day of interdisciplinary research, biologists must continue to work with economists and with sociologists and other social scientists as integral members of a team attempting to solve the food problems of the world.

Discussion: Nutrition and Food Science Implications

Doris Howes Calloway

A previous speaker has noted that there were only thirty agricultural economists involved in the World Food and Nutrition Study (WFNS). Even though "Nutrition" is half of the title, there were only five and a half nutritionists involved and, incidentally, only six women. Our study team 9 had two and a half nutritionists (one did double duty as an anthropologist) and half of the total women involved in the study. It is no wonder, then, that issues relating to women received little attention and that, apart from team 9's efforts, neither did nutrition.

Nutritionists must assume much of the responsibility for the fact that issues concerning food and its relation to human sustenance have been neglected by other professionals. Nutrition scientists have tended to remain in their laboratories, developing basic information on what substances are essential in the diet, what amount must be taken daily, and what metabolic purpose is served. "Basic research" workers have not spoken out on the societal consequences of failure to meet nutritional needs and, in fact, many may not even be aware of them (any more than an organic chemist, for example, might know about and speak to issues stemming from the use of pesticides). People working in applied nutrition might be expected to know these things, but applied nutritionists have for the most part been women who are often shy of speaking or whose remarks go unheard by those in a position to act, to make change.

More recently, the most prevalent form of malnutrition—that due to inadequate food intake, to limitation of food energy—has been seen to be unnecessary and capable of elimination. Many people have urged that a concerted effort be made to do so, and the United Nations is committed to this effort. Economists have looked to justify it as economic, not simply humanitarian. Assessment of economic costs relates to present views that short of death severe malnutrition leads to permanent impairment of physical and mental development so that society is burdened with the underproductive survivors. Sadly, the nutritionist is unable as yet to give definitive answers as to the individual and social consequences of less than severe malnutrition. Sadly for the economist, it is difficult for him to justify increasing the productive capability of someone who, in fact, will be unemployed and unproductive. Yet there is no doubt that these consequences are profoundly undesirable. Even our mutual security is threatened by the existence of malnutrition elsewhere.

Study team 9 was drafted to be interdisciplinary, with the sanction of the Academy but largely under advisement of Alan Berg, our chairman. His stance was consistent with a view that has been emerging among international and bilateral agencies (under the urging of a handful of key professionals, mainly economists) that sustained improvement in nutritional state of deprived people will not result from conventional nutrition/health sector interventions but will, rather, require that general governmental policies and programs be designed specifically with nutrition objectives in mind. Team 9 took a new view of nutrition research, seeing it as needing to provide the information required to indicate what the policy choices are, to provide the criteria for selecting among alternatives, and to suggest measures of effectiveness. This new kind of nutrition research obviously requires the involvement of many specialists, notably agricultural economists and nutritionists. Food scientists should review their research priorities in the same light.

Five research profiles in nutrition and food science have been selected by the Academy Steering Committee as deserving immediate attention. These are the functional significance of malnutrition or nutrition-performance rela-

Doris Howes Calloway is a professor and chairman of the Department of Nutritional Sciences, University of California, Berkeley.

tions, the role of specific dietary components in the context of total diets, the nutrition impact of governmental policies, evaluation of nutrition intervention programs, and reduction of food losses between production and consumption. Several other profiles have nutrition/food science content, but none of these offers the hope for immediate nutrition gains as those cited. Of all works proposed, the Steering Committee gave its highest priority to the research needed to link food intakes with nutritional states and to determine the biological and societal consequences of failure to meet needs. I agree.

Discussion: Enhancing Natural Resource Use to Increase World Food Production

Jan van Schilfgaarde

The natural resources available to grow food—land, water, and energy—are finite in extent, and their use for agriculture is often in competition with other uses. Recent inventories suggest that 3.4 billion hectares, or 25% of the world's land surface, in principle could be cultivated; at present the cultivated area is less than 11%. The potential for expansion of cultivated area is substantial, but much of this land is not where the people are; furthermore, its development could readily lead to drastic and irreversible resource deterioration both on site and off. A similar situation prevails for water. The currently 170 million hectares of irrigated land could be doubled but not without tremendous investment and substantial risk. The obvious alternative for increasing food production is to increase production per unit of land. Both avenues must be pursued.

Two divergent, yet related, concepts are often advocated: to transfer the technology of U.S. commercial agriculture to other regions and to greatly expand basic biochemical research—photosynthesis, nitrogen fixation, genetic engineering—in "pure" academic institutions. Both have their proper place in increasing food production, but they must be placed in perspective. I propose that higher priority be given to learning to use natural resources effectively and conservatively by adapting known principles imaginatively to existing ecological and socioinstitutional circumstances and by further developing these principles to aid in constructive development. This approach is less direct and more difficult than transferring large-scale mechanization and less glamorous than biochemistry. It calls for inputs from more than the physical and biological sciences—from economics, if you wish, but not for myopic benefit-cost analysis.

Some examples may clarify the issue. In Nigeria, it is not uncommon to encounter 50 plant species that make up a farming system for a small community. Introducing monoculture techniques would be socially and agronomically disastrous, as well as exposing the land to severe erosion. But the recent development of a hand-operated drill for precision planting in mulch or sod can greatly increase labor productivity. Combined with a back-carried herbicide sprayer that applies 10 liters per hectare (as compared with the more usual 500 liters per hectare), the energy required for planting is reduced more than tenfold, while production is increased by improving the existing multiple cropping system.

Pereira related an experience in Kenya, where some twenty years ago forest vegetation was transformed into a tea plantation, using the best conservation practices known. Peak runoff flows quadrupled during clearing and planting and still were double those from forested watershed after a full canopy was established, even though consumptive use was equal. Brazil is committed to developing 3 million hectares of Oxisol savannahs of their Cerrado by 1979 and 50 million by 2000; Peru plans to develop 2 million hectares of its Amazon jungle by 1990. Do we know how to avoid adverse consequences? If we do, can we implement the proper measures?

In Puerto Rico, intercropping a new planting of coffee with plantains the first two years, and taniers the third, increased net income more than $8,000 per hectare over the three-year period. Furthermore, imaginative management practices resulted in subsequent annual coffee yields ten times the regional average. Thus, the potential has been demonstrated of significant impact on production by adapting imaginative concepts to existing farming systems. So have the dangers of large-scale changes without full realization of the consequences.

Within this framework, exciting possibilities exist for research to realize the full potential of

Jan van Schilfgaarde is the director of the U.S. Salinity Laboratory, U.S. Department of Agriculture, Riverside, California.

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the available resources, natural and human. The thrust of such research should be to help the independent, generally relatively small farmer improve his productivity with a minimal dependence on capital-intensive external inputs. This certainly does not obviate the need for sophisticated and basic research.

A key problem, especially in the tropics, is to provide adequate plant nutrition. In view of dwindling (and high priced) supplies of petrochemicals and phosphate rock, one valid approach involves accelerated research to manufacture ammonia more efficiently and from feedstocks other than natural gas and to improve the inexcusably wasteful methods prevalent in the phosphate mining industry. An alternative, of at least equal merit, is to use the resources at hand to reduce the dependence on artificial fertilizer. The amount of major nutrients in organic wastes in 1971 was eight times that in the fertilizers sold. In the United States, the nitrogen excreted by animals in confinement was about two-thirds that sold as fertilizer. Clearly, the potential for improved waste recycling techniques is large. Furthermore, research on the use of bacteria (rhizobia) to enhance nitrogen fixation and fungi (mycorrhizae) to increase phosphorus uptake by roots has tremendous potential for improving plant nutrition without dependence on expensive or even unavailable inputs; such research requires a high level of sophistication, but the results lead directly to simple field application.

Another opportunity concerns the adaptation of crop plants to environmental stresses. Historically, plant breeding has emphasized selection to fit an environment in which stresses—nutrient deficiencies, water, salinity—have been minimized. The selection of grains for aluminum tolerance and some preliminary results showing a wide range of salt tolerance among barley strains indicate the potential of fitting the plant to the environment rather than the reverse.

Considering irrigation, the need is for efficient use of water in the first instance. Current practices result in substantial waste of both water and energy and unnecessary degradation of land and water. The problems are partly technical, but, as illustrated by Reidinger, institutional and economic issues frequently dominate.

Space does not permit further examples, but clearly there are tremendous opportunities as well as many problems in increasing productive use of limited natural resources within the framework of socially acceptable farming systems—problems that require technical innovation but, just as urgently, imaginative inputs from social scientists. Some of these are close at home, like the need to provide adequate incentives for academicians to address multidisciplinary real world problems; others focus elsewhere, where textbook economic analyses have often aggravated rather than resolved unhappy situations.

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Discussion: Social Science and Related Implications

Lowell S. Hardin

What we are discussing is a U.S. public policy document. Its message reinforces and is complemented by the rising concerns of nonfarm groups. The right to food is discussed as a component of the human rights package. The World Food Council, some think, may become a serious forum for north-south dialogue. There is hope that Public Law 480 may become a food for development program with decreased emphasis on surplus disposal and diplomatic leverage. More importantly, international interdependencies among nations and societies are increasingly understood. Thus, a variety of forces is at work to place at least part of the World Food and Nutrition Study's (WFNS's) recommendations on the national policy agenda.

In an effort to improve the performance of development aid, donors are demanding more sophisticated and rigorously prepared projects and programs. The capacity of many less developed countries (LDC's) to meet these standards is still limited. As a result, there has developed an increasing flow of development aid searching for suitable programs and projects. Equation of demand and supply cannot rely in the long term on transitory expatriate expertise. Rather, domestic LDC capacity to meet this need and tap into the global community of science, technology, and governance must increase. Much of what the WFNS recommends is intended to speed this process. But the new aid resources coming on stream will have to show at least some results rather soon if desired momentum is to be sustained.

Against this background, I have four observations. First, as agricultural economists we may well be challenged to provide more than we are prepared to deliver. Scientific and technological advances of biophysical and engineering types, while exciting, critically important, and likely to be forthcoming, are in themselves insufficient to the task. Nontechnological constraints may well be the critical ones. Involved are proper public policies in the rich as well as in the poor countries and development of the institutions, programs, and projects they foster. Biophysical scientists frequently speak with conviction when they say: "We have the technological package right. All that is holding it back is wrongheaded price, trade, tax, land tenure, exchange rate, or investment policies." Often economists are the first to agree. We also know, however, that much technology has been unsuccessfully promoted because it was not well tailored to the agroclimatic and socioeconomic circumstances of the intended users.

Second, what we seek and what our fellow social and biophysical scientists are urging upon us is joint involvement in capacity building and research. In this connection the experience of the International Agricultural Research Centers is instructive. Through high-quality biophysical research, much of it adaptive, some key technological advances are identified. At the national level, however, changes in the nontechnological components of the production/distribution system are required in order to take full advantage of the improved technology. At the invitation of national programs, the centers' social and biophysical scientists work with the nation's scientists and policy makers to put the nontechnological components into the total package. Thus, the initial technological advance catalyzes institutional and policy changes. Such technology-led changes are part and parcel of an imperfect institutional development process. They often make it easier for the right questions to be asked, heard, and acted upon. Effective participation by social scientists requires familiarity with the technology at hand and understanding of what is in the pipeline.

Third, for effectiveness, agricultural economists and social science colleagues need to enter the scene on an *ex ante* rather than an *ex post* basis. Biophysical scientists seldom take kindly to the social scientist who, absent

Lowell S. Hardin is a program officer for agriculture, the Ford Foundation, New York.

at preimplementation stages, comes in for the evaluation and tells everyone else what they did wrong. Of course, social scientists are involved in diagnosis, planning, and *ex ante* assessment of the consequences of change, but my plea is for even greater *ex ante* responsibility bearing and involvement.

Fourth, as social scientists we almost instinctively invest heavily in self-examination. Generally, the outcome is constructive. But to my view we should not let this process deter us from getting on with the job. Given the inadequacies of development theory and the limited knowledge of how to induce desired institutional change, we still have to learn by trying, by ferreting out what works and why.

Concluding, I view the study as a successful interdisciplinary effort. Having worked on the PSAC World Food Study of 1967, I have learned not to expect miracles. I do think, however, that international food and nutrition research and development is being made more legitimate, mostly for the right reasons. As this occurs, we may have to run to catch up. That is precisely what I would like to see happen.

Farm Family Response to a Negative Income Tax
(D. Lee Bawden, The Urban Institute, Chairperson)

Purpose and Design of the Rural Income Maintenance Experiment

D. Lee Bawden and William S. Harrar

The Rural Income Maintenance Experiment (RIME) was the second of four major experiments to test the behavioral consequences of a universal income-conditioned cash transfer program. It followed closely its predecessor, the New Jersey Income Maintenance Experiment, in objectives and design. Of the four experiments, it is the only one focusing on the rural sector (farmers and those in towns with population less than 2,500).

This paper describes the setting that spawned experimentation with a universal income-conditioned transfer program (commonly referred to as the negative income tax), gives the rationale for the RIME, and sets forth its objectives and basic design.

Origins of Negative Income Tax Experimentation

The negative income tax experiments originated in the mid-1960s. Public assistance programs in the United States had come to be regarded as illogically conceived, poorly administered, and inequitably applied. Over half of the poor people in the United States were receiving neither public assistance nor food stamps. Of those that were—mainly from Aid to Families with Dependent Children (AFDC) and Old Age Assistance (OAA)—some families were receiving eight times the assistance of other families of similar size and pre-transfer income merely because of regional location. Except for a meagerly funded and unpublicized AFDC-UP program in about half the states, households headed by able-bodied males under 65 years of age—the so-called working poor—were ineligible for public assistance; yet two out of every five poor people in the United States were in such households.

Out of this dissatisfaction, interest grew in an income maintenance program that was open to all poor people and that had simplified eligibility requirements. A universal negative income tax emerged as the most promising alternative among several, partly because of its ability to more efficiently channel funds to the low-income population and partly because of its inherent logic as a downward extension of the positive income tax. In its simplest form, a negative income tax embodies two principal features: a guarantee or basic benefit, which varies by family size and is available to families who have no income, and a tax rate, which is the rate by which this basic benefit (guarantee) is reduced per dollar of other income received by the family. (Thus, a 50% tax rate means that benefits are reduced by $0.50 for each $1.00 of income received by the family from other sources.)

The major reason for experimentation was that a negative income tax—because of its relatively high "tax" on earnings—would likely have some negative effect on work effort. But no one knew how much. The cost of any given negative income tax program is dependent on the amount of work disincentive that it would induce. Moreover, the choice of the appropriate parameters of such a program (the guarantee and tax rate) depended in part on the relationship of work disincentive to those key parameters. A large-scale experiment would permit identification of the effect of alternative negative income tax programs on work effort, as well as on the attitudes and other behavior of low-income families.

These were the major reasons that the Office of Economic Opportunity in 1968 ini-

D. Lee Bawden is the director of Human Resources and Income Security, The Urban Institute, Washington, D.C., and William S. Harrar is self-employed in San Francisco, California.

tiated an experiment in urban areas of New Jersey and Pennsylvania that focused on families headed by able-bodied males between 18 and 58 years of age.

Rationale for the Rural Income Maintenance Experiment

The New Jersey experiment was expected to yield a great deal of information about the effect of various negative tax plans on behavioral and attitudinal characteristics of urban wage earners. But these results were not expected to be directly applicable to the rural sector, in which over one-third of the nation's poor reside.[1] Differences between rural and urban residents in their work responses to such a program were expected because of differences in alternative employment opportunities and in the proportion of self-employed people. An accurate estimate of the magnitude of disincentive, both rural and urban, was necessary to estimate the cost of a nationwide program.

Also, it was not clear whether some features of a program most effective for addressing urban poverty problems were best suited for addressing rural poverty. For example, a large number of rural residents with low incomes are operators of farms or businesses in small towns. Determination of annual income as well as the appropriate timing of payments for the self-employed are different than for wage earners. This is especially true for those farmers who receive their entire annual income at harvest time.

These needs for experimentation in a rural setting in conjunction with the urban experiment in New Jersey led to a planning grant from the Ford Foundation to the Institute for Research on Poverty, University of Wisconsin. Under the Ford grant, ten staff members at the University of Wisconsin, all affiliated with the Institute for Research on Poverty and representing the disciplines of economics, agricultural economics, sociology, political science, law, and social work, combined in an interdisciplinary effort to design the rural experiment. The experiment began in late 1969 and extended over a four-year period, with payments made to families for thirty-six months. The total cost of the project was about $5.5 million, financed initially by the Office of Economic Opportunity and later by the Department of Health, Education, and Welfare.

Description of the Experiment

The primary objective of the RIME was to measure the effect of alternative tax rates and minimum guarantees upon the work behavior of rural residents, both wage-earners and farmers. Of secondary importance were a host of other objectives, among them being to learn the effect of payments upon (*a*) the children of the poor—their health, school performance, peer and reference group involvements, attitudes towards authority, delinquency rates, vocational aspirations, and numerous other characteristics; (*b*) changes in expenditure patterns—the distribution between savings and consumption, marginal expenditures on medical care and housing, and credit versus cash buying; (*c*) job search behavior; (*d*) farm production and financial decisions; (*e*) nutrition; (*f*) family structure (separation and divorce rates); (*g*) geographic mobility; (*h*) psychological well-being; and (*i*) political involvement.

Two locations were chosen for the experiment. The alternative of taking a nationwide rural sample was rejected in deference to administrative ease and a smaller operating budget. By selecting two locations, regional and ethnic differences in work incentives and other behavioral characteristics could be tested. The South was chosen because it contains a higher incidence of rural poverty than any other area in the United States and because over half of the rural poor reside there. The Midwest was selected because it is, as classified by the U.S. Department of Agriculture, a relatively affluent area with a poor white minority.

The sample was drawn from Duplin County, North Carolina, and two contiguous counties in the more sparsely settled Midwest (Calhoun and Pocahontas Counties, Iowa). Criteria for selecting the counties included the size and number of rural towns, their proximity to large cities, density of the farm population, diversity of agriculture, and representativeness of the entire region with respect to incidence of poverty, unemployment, racial mix, age distribution, and educational level.

Families were selected randomly from the

[1] In 1969 the rural population represented only 26.6% of the total U.S. population but contained 35.5% of the poor people.

predesignated areas and were deemed eligible for the program if their incomes were less than one and one-half times the established poverty line. Eligible families were then randomly assigned to a control group or to one of five treatment plans, involving combinations of three tax rates (30%, 50%, and 70%) and three guaranteed minimums (50%, 75%, and 100% of the poverty level). The plans are shown in table 1 along with their 1969 minimum dollar guarantees and breakeven levels for a family of four. Families remained on the plan to which they were initially assigned for the duration of the experiment, and they were eligible for payments for the thirty-six-month period regardless of their subsequent geographic location, as long as it was within the United States.

A total of 809 families were selected; 54% were assigned to the control group, and 46% were distributed among the five treatments. The sample was stratified by income level, age of head, and region. Sixty-two percent of the sample was allocated to North Carolina, 38% to Iowa. Seventy-two percent of the families were headed by an able-bodied male age 18 to 58, 13% were headed by a female of the same age range, and 14% were headed by a person of either sex over age 58.

Payments were based on income and number of members of the "filing unit." The central family of the household (husband, wife, and minor children) were one filing unit and received one payment; other household members—those over age 20 or over age 17 if married—were separate filing units and received their own separate payment but at a reduced level. If the latter left the original tax unit, they became eligible for the full head-of-household payment level. A family head or spouse who left the original family unit was eligible for a payment of one-half the amount that a head and spouse together were entitled to when both were in the unit. After one year of separation, they each were entitled to a full head-of-household payment.

Income and filing unit size were reported every month to a payments office. Income was defined as total gross income in cash or in kind from all sources minus business expenses. The self-employed also reported depreciation and other noncash costs once a year after filing their personal income tax returns. Ten percent of net capital wealth was added annually to income to represent potential capital consumption. However, the first $20,000 of business assets, the first $10,000 equity in owner-occupied homes, $1,000 in cash or savings, and all personal effects were excluded from net capital wealth for purposes of this imputation. A portion of out-of-pocket medical expenses were deducted from income. Federal and state income taxes were reimbursed on a dollar-for-dollar basis.

All filing units were paid semimonthly, with married heads receiving one check made payable to husband and wife jointly.

The basic accounting plan—the period for computing income upon which payments were based—was the same for both the rural and urban experiments: a three-period moving average, each period representing four weeks (or one month). However, the income accounting procedure in the RIME embodied a "carryover" provision. Earned income in excess of the breakeven level was carried forward for a maximum of one year and was added to income in any period in which such income fell below the breakeven level. Negative income payments were based on earned income plus any amount assigned to that period from the carryover. This was a major innovation in the accounting procedure from the New Jersey Experiment, necessitated by the uneven flow of income of the self-employed.

Adult members of the households (all those over age 15) were interviewed quarterly to

Table 1. Program Alternatives

Guarantee (% Poverty Level)	Tax Rates (%)		
	30	50	70
	Guarantee Level/Breakeven ($/Year)[a]		
50		1,741/3,482	
75	2,611/8,703	2,611/5,222	2,611/3,730
100		3,482/6,964	

[a] Breakeven is the level of the family's own income at which the negative income tax payments become zero. The guarantees were adjusted upward each year of the experiment by the rise in the consumer price index.

gather information on the previously mentioned attitudinal and behavioral characteristics.

Empirical Analysis

A number of researchers, both at the University of Wisconsin and at other universities, participated in analyzing the effects of the experiment. The results are reported in forty-one separate papers, to be published by the Institute for Research on Poverty.[2] The three papers that follow summarize three of the forty-one papers. They are among the most important for they focus on the effect of the experiment on the work and income of farm families and on their business and financial decisions.

[2] Copies of these papers are available from the Institute at a nominal cost. The data base is also maintained by the Institute, and a staff is available to prepare extracts for interested researchers. The cost will vary depending on the size and complexity of the extract.

The Effect of a Negative Income Tax on Farm Business Decisions and Financial Management

William E. Saupe

The purpose of these analyses is to provide a basis for judging the effect of a negative income tax experiment on farm business and financial management decisions. Of concern here are the effects on level and mix of farm production, on changes in asset-debt relationships, and on sources and purposes of farm loans. Theoretical expectations were reported by Meyer and Saupe, Bawden (1970, 1971), and Kerachsky (this issue) and are not repeated here.

Multiple regression analysis was the major analytical device. All models contained a set of theoretically plausible explanatory variables to control for any differences in farm resources or demographic characteristics between controls and experimentals plus variable(s) for the tax and guarantee levels in the experimental plans. Observations from Iowa and North Carolina were not combined in the analyses because of substantial differences in the underlying agricultural production relationships.

Explanatory Model

The analytical models and empirical findings are reported in detail elsewhere (Saupe) and are briefly summarized in this article. An example of the general explanatory model is presented in table 1. In this illustration the dependent variable is the value of all farm product sales in the middle year of the experiment.

William E. Saupe is a professor of agricultural economics and a staff member, Institute for Research on Poverty, University of Wisconsin, Madison.

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Race of head was included among the demographic variables in North Carolina, where being black was associated with $4,804 less farm sales, a substantial amount relative to the mean of $8,300. In North Carolina an additional year of formal education was associated with $438 of additional sales, but this variable was not significant in Iowa. Being confined to bed by sickness an extra day reduced sales by $78.60 in Iowa but was not significant in North Carolina.

In North Carolina, neither acres of tobacco nor acres of other crops significantly affected farm sales, but the operator's share of the crops produced was significant in both states. In Iowa, an extra acre of cropland added $43 to total sales; a marginal dollar of investment in specialized livestock equipment added 22¢ to sales; and an extra dollar of equity in the base period added 7¢ to farm sales.

Three dummy variables representing the experiment's tax rate-guarantee plans grouped by their approximate "generosity" are included in the example model (table 1). The variable scheme used here was appropriate for the range of income observed among the experimental farmers. The "low generosity" plans were the 50–50 and 70–75 tax rate-income guarantee plans. The 50–75 was the "medium generosity" plan. The 30–75 and 50–100 plans were combined into the "high generosity" group. Other parameterizations tested, but not illustrated here, were a single dummy variable for being in any experimental plan and a set of five dummy variables, one for each experimental plan.

Interpretation of the effect of the experiment does not have to be based on a single model such as table 1. Also of interest are the pervasiveness of an experimental effect over the three years of the experiment, among different parameterizations of the tax rate-guarantee plans, the sensitivity of the effect to

Table 1. A Model for Farm Product Sales in the Middle Year of the Experiment, North Carolina and Iowa

Independent Variable	North Carolina		Iowa	
	Regression Coefficients	Significance Levels	Regression Coefficients	Significance Levels
Race (black = 1)[c]	−4,804.0	<0.01	—	—
Age (years)	92.0	0.89	−94.5	0.85
Age squared	−1.7	0.81	1.2	0.84
Years of formal education	438.0	0.11	15.4	0.96
Persons supported	−13.8	0.98	−132.3	0.06
Days sick in bed	−13.1	0.81	−78.6	0.06
Acres of tobacco, 1969	191.0	0.72	—	—
All other crop acres, 1969	−0.36	0.99	43.0	<0.01
Operator's share of crops	8,650.0[a]	0.03	−6,835.0[b]	<0.01
Livestock investment, 1969	−0.05	0.96	0.22	0.03
Equity in 1969 ($)	−0.08	0.40	0.07	0.10
Index farm machinery size	—	—	560.7	0.25
Hours farm labor, 1969	2.01	0.42	2.1	0.43
Hours farm labor squared	−0.0001	0.53	0.0002	0.75
Nonfarm income, 1969	−0.49	0.31	0.27	0.70
Experiment				
Low generosity plans	−4,109.0	0.04	3,373.0	0.05
Medium generosity plans	−1,152.0	0.55	−1,285.0	0.50
High generosity plans	−1,728.0	0.30	−2,042.0	0.17
Constant	−451.0	0.98	9,693.0	0.42
N	111		109	
F-ratio	4.0		20.8	
R^2	0.42		0.78	

[a] If the operator received 100% of the crops as his share (i.e., a full owner), his farm sales would have been increased by $8,650.
[b] If the operator rented 100% of his cropland on shares, his farm sales would have been reduced by $6,835.
[c] The first six variables pertain to the head of household.

the particular form of the model, to the specification of the variables, and to the addition or deletion of a small number of observations from the groups being studied.

There are relatively small numbers of observations in each cell—from six to fourteen per experimental plan and from thirteen to twenty-four in the generosity groups. The problem of the reduced probability of observing a significant response given a "true" response thus becomes acute. Under these circumstances, the reader may want to accept significance levels of 0.25 or 0.30 that an observed phenomenon is an experimental effect.

Farm Product Sales

The experiment was found to reduce levels of farm product sales in both states but to have opposite and partially offsetting effects on levels of crop sales and on livestock sales (table 2). In Iowa, farmers responded with increased sales of crops, which were more than offset with decreased sales of livestock. In North Carolina, farmers decreased sales of tobacco and other crops, which were not offset by the smaller increased sales of livestock, also for a net decrease in farm product sales.

Table 2 may be considered a summary of many other analyses and tests. Some decisions affecting livestock sales in 1970 had been made prior to the start of the experiment in Iowa, e.g., purchase of fattening cattle and selection and breeding of swine. This would tend to dampen any response in 1970. In Iowa, the decrease in livestock sales associated with the experimentals increased both in magnitude and significance during the experiment (table 2).

Major livestock enterprises in the Iowa counties in the experiment were the farrowing

Table 2. Regression Results for Control/Payments Dummy Variables in Models of Farm Product Sales

	Products			
	Tobacco[a]	All Crops	Livestock	Crops Plus Livestock
Iowa				
1970				
Coefficients	—	$310	−$473	−$163
Significance[b]		0.65	0.70	0.90
1971				
Coefficients	—	$670	−$954	−$285
Significance		0.50	0.40	0.82
1972				
Coefficients	—	$1,251	−$2,454	−$1,203
Significance		0.37	0.21	0.52
North Carolina				
1970				
Coefficients	−$981	−$1,137	$28	−$1,108
Significance	0.05	0.04	0.94	0.07
1971				
Coefficients	−$2,126	−$2,296	$32	−$2,265
Significance	0.06	0.07	0.94	0.08
1972				
Coefficients	−$898	−$1,447	$437	−$1,010
Significance	0.29	0.31	0.38	0.50

[a] This includes both the effect of farmers quitting production and the effect of remaining in production but producing less.
[b] Significance level using a *t*-test.

or purchase of pigs and feeding them to market weights and purchasing feeder cattle (generally in the fall) and feeding them to slaughter weights and selling the following year. Being in the experimental plans was associated with a lower conditional probability of selling any market hogs. Among the farms selling market hogs, experimentals sold substantially fewer in all three years, when preexperiment differences were controlled for. Fewer of the Iowa control and experimental farms fed any cattle, and the analyses were less conclusive. The number of cattle marketed appeared to be lower for farmers in the experimental plans, however.

"Minor" livestock enterprises were enterprises that were small relative to the usual size of that livestock enterprise on all farms in the county and also were a relatively minor part of the total farm business on the farms studied. The conditional probability that a farm had any minor livestock enterprises was not affected by being in the experimental plans in any year in Iowa.

In North Carolina, tobacco dominated other crops in gross sales per acre at well over $1,000 per acre, five times greater than for any other crop. Tobacco production was controlled by federal allotments, which could readily be transferred from farmer to farmer. Being in the experimental plans was associated with substantial reductions in tobacco sales and all crop sales in all three years (table 2).

Livestock sales in North Carolina were not statistically different between controls and the experimentals in all three years. Hog production was the most common livestock enterprise and it appeared generally unaffected. The conditional probability of having minor livestock enterprises, and the number of such enterprises, was greater for the experimentals in 1970 and 1971 but the effect on total sales was minimal.

Farm Financial Management

The management of farm business finances and farm family finances are usually intertwined. Every expenditure for consumption, farm-operating expenses, or farm investment draws from the same pool of receipts. For example, a change in total farm family income

caused by being in the experiment may influence farm net worth by a change in farm assets or farm debts. But the change may instead be in current consumption, purchase of consumer durables, or investment in human capital, with farm assets and debts unchanged. Thus, the experimental effect cannot be predicted.

Iowa farmers in the experimental plans increased farm net worth $4,415 less than controls during a forty-five-month period in the experiment from 1969 to 1973, after controlling for the different initial endowment of assets and other control-experimental differences. The *t*-significance level of this coefficient was 0.12; mean net worth at the end of the experiment for experimental and control farmers combined was $33,920. The percentage increase in farm net worth for experimentals was also less than controls. In North Carolina the net worth increases of controls and experimentals were not different in a statistically significant way.

The effect of the experiment on farmers' debt to asset relationships also can be measured but cannot be predicted. In general, the ratio reflects the farmer's and the agricultural lender's view of risk and the expected marginal returns from capital. The analyses gave some indication that Iowa control farmers increased their debts relative to assets more than experimentals. There were no significant differences in the debt-to-asset ratios of controls and experimentals in North Carolina.

Information about sources and purposes of farm business loans was asked for directly in the interviews. Questions were asked about lending institutions, the amount owed, and the reason for borrowing from that institution. Loan companies usually do not provide on-farm supervision or farm management advice with their loans and are often associated with relatively disadvantageous interest rates and repayment schedules. The Farmers Home Administration (FmHA) makes farm loans to applicants who are unable to obtain funds from banks and conventional lenders but who do appear to have farm business potential. In the years of the experiment, the FmHA also provided some on-farm loan supervision and business analyses for their clients.

For the established farm borrower, the improved financial position caused by being in the experiment might permit him to move from less desirable to more desirable lenders. The improved financial position might raise a previously high risk nonborrower to the minimum position where he becomes acceptable to (say) loan companies but not to banks. In Iowa, experimentals reported substantial reductions in the amount borrowed from loan companies between 1970 and 1972 and used this source relatively less than the controls in 1972.

In North Carolina there was a net increase of five experimentals reporting farm loans from any sources from 1970 to 1972 while controls remained unchanged. Regression analyses controlling for between-group differences established that experimentals on average increased their farm business loans $1,145 more than controls from September 1970 to September 1972 (*t*-significance of the controls-experimentals dummy variable = 0.30). Because experimentals started from a smaller base of loans in 1970, their percentage increase was substantially greater than for controls.

The major difference between controls and experimentals in North Carolina was that experimentals increased their use of the FmHA and loan companies relative to controls. The dollar change in borrowings from the FmHA was regressed against a set of relevant explanatory variables, and experimentals increased borrowings from them $996 more than controls (*t*-significance level = 0.19). A regression analysis of dollar change in borrowings from loan companies resulted in a $458 greater increase for experimentals over controls (*t*-significance level = 0.12).

In both states controls and experimentals were little different in their reasons for farm borrowing. Both increased their borrowings for purchase of land, buildings, and machinery. In North Carolina, both groups increased borrowing for automobile purchase and repair, but the changes were more pronounced for experimentals. The number of experimentals borrowing for this purpose increased from seven to twenty-three from 1970 to 1972, and they increased average borrowing for automobiles $587 more than controls during this period, controlling for other relevant differences (*t*-significance = 0.01).

Implications for a Universal Program

There were about 0.6 million farmers with total family income below 125% of the federal poverty level in 1975 (based on U.S. Dep. Commerce). The number eligible for a universal income-conditioned cash transfer program

would depend on the provisions of that program. However, the aggregate farm production responses to any politically feasible program would probably not affect farm production levels or food prices. First, the smaller (presumably lower income) farmers in the United States account for a very small percentage of total farm product sales (Daly). Second, the reductions in farm production noted in the experiment tended to be small and in some cases were shifted to nonexperimental farmers, e.g., tobacco allotments. In spite of a generally inelastic demand for food, the aggregate effect would be minimal.

Associated with the improved financial position of the experimentals, there was a willingness on the part of the farmer and his agricultural lender to begin or increase use of agricultural credit. Avoiding suboptimal use of this new credit would increase the effectiveness of a universal transfer program in increasing the economic well-being of the farm families. The successful experiences of the Farmers Home Administration with intensive loan supervision and of on-farm educational programs in farm financial management for smaller farms suggest that such an opportunity would exist.

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Work and Income

Wendell E. Primus

This paper provides estimates of the effect that a negative income tax (NIT) has upon farm work and income. Experimental effects could be substantially different from that of a national income maintenance program for a number of reasons. (*a*) Three years, including an adjustment and learning process, may be too short a time horizon for farmers to completely adjust their farming enterprise to the different prices caused by the experiment. (*b*) There is evidence that families may not have understood how the transfer scheme operated. With a saturated national program, the level of knowledge might be different (Harrar). (*c*) Measurement errors in the collection of the data may result in erroneous conclusions being reached.[1] The theory supporting this analysis has been discussed elsewhere (see Evans; Kerachsky; Primus 1977, 1975).

Conventional consumer theory used in many labor supply models predicts a decline in total labor supplied by a farm operator under an NIT. Among different farm enterprises, the greatest reduction in labor input will be felt where the value of the marginal product for labor is smallest and where adjustment in size of farm enterprise is easiest. Enterprises with large illiquid and inflexible capital requirements should experience the least change in scale of operation.

Estimation Methodology

The prime tool for these analyses was a time-series, cross-section pooling regression program developed from Nerlove. The sample contains all farm families with a male head less than or equal to 72 years of age at the end of the experiment, who farmed each year, had constant marital status, and had at least 400 hours of farm work in one of the years between 1969 and 1972.

Each year of the experiment for each farmer constitutes one observation. This has the advantage of increasing degrees of freedom and allowing the behavioral response to the program over time to be traced. The number of individual farmers in North Carolina is 94: 42 were control and 52 experimental. In Iowa the number of control families for this analysis is 54, while the number of experimental families is 50.

Because of the different production functions and methods of production, the Iowa and North Carolina samples were split. Tobacco growing is primarily a labor-intensive operation, while corn growing in Iowa is a highly capital-intensive operation.

One of the methods for analyzing the effect would be to construct a demand-supply model. A properly constructed model could estimate the treatment coefficients, taking into account the simultaneous decisions, amounts of labor, capital (both long and short run) being allocated to each of several farm enterprises, including off-farm work by various members of the farm family. However, given only income and expense data in monetary terms, the *ex post* nature of the data, the failure to collect input data by enterprise, and poor measures of capital, it is difficult to estimate the structural equations with a sufficient degree of accuracy. Thus, the prime focus of this study is to estimate accurately the treatment parameters in a reduced-form model.

The basic form of the model is $D = f(C, E, C^*E, R)$, where D is a measure of farm income or effort, C are control variables, E are experimental variables, C^*E are control and experimental interactions, and R is a reporting variable.

Control variables are included to insure that differences between the control and experimental samples, which occurred as a byproduct or accident of random sampling, are not included in the coefficients on the treatment

Wendell E. Primus is a consultant to the Office of Survey Development, Office of the Assistant Secretary, Planning and Evaluation, Department of Health, Education, and Welfare.

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[1] Measurement errors in the data were significant. Net farm income was changed by an average of $1,312 in North Carolina and $2,633 in Iowa through the editing process.

variables. These variables are often important determinants of the dependent variables. Without their inclusion, the equations would suffer from specification error resulting in biased experimental variable coefficients. These variables included a measure of 1969 work effort, age and education of the farm operator, debt-to-asset ratio, net farm equity, change in off-farm work, and dummy variables representing time.

Experimental variables are different formulations of the tax and guarantee parameters. Interactions are needed between the two groups of variables to test for differences between subpopulations (e.g., race) or as further refinements to determine where the treatment response took place.

A reporting variable was added to explain some of the variation in the experimental group response. A look at the distribution of hours worked for 1970–72 versus 1969 for the experimental group shows a considerable variation. Some experimental families increased their hours substantially, while other families' hours declined substantially. Farmers who intentionally or unintentionally misreport income to the payments process via their monthly income report forms might behave differently. Given the edited estimates of quarterly income (see Primus 1975 for a complete discussion of editing techniques), an estimate of the amount of payments farms should receive can be estimated.[2] Based upon this, some farmers received $1,000 more in payments than they should have received.[3]

Theoretically, these experimental farmers are facing a different marginal tax rate than their assigned tax rate. A change in their true income does not affect their payment as the subscribed mathematical formula underlying the NIT transfer scheme would indicate. Consequently, their behavioral response will be altered as compared with other farmers in the experimental group. The income effect would still be in effect, but the substitution effects would dissipate, the extent to which would be based upon the amount of misreporting and closeness to the breakeven level. As a partial control for this phenomenon, a variable was added that is actual minus predicted payments divided by the mean of the two variables.

Results

The conclusion relating to the experimental effect upon farm effort is sensitive to the measure of farm hours used: budgeted hours and recall hours. Each year, the respondents were asked the number of acres grown in each crop and the number of different kinds of livestock that were sold. By obtaining a coefficient from other published sources, an estimate of the number of hours a particular farming enterprise required was constructed. Adjustments for size and kind of capital equipment and amount of hired labor on the farm were also made. Thus, "budgeted hours" represent the labor input of the entire family to the farming enterprise. The chief disadvantage of using this variable is that farm overhead labor, such as building maintenance, repair of general purpose tractors, or gathering of market information, is not taken into consideration. This may not pose a problem if one assumes that overhead is simply proportional to the scale of operation.

The experimental effects on budgeted farm hours for each region, controlling for preexperimental factors, are summarized in table 1. The percentage differential can be interpreted

Table 1. Percentage Differential in Budgeted Farm Hours

	North Carolina (%)	Iowa (%)
Crop hours	−15.1[a]	−2.1
Livestock hours[b]		−15.8[c]
Total hours	−12.7[c]	−8.0[a]
Adjusted total hours[d]	−5.9	−11.5[a]

Note: Percentage differential can be interpreted as the average change in hours for the experimental group relative to the control group.

[a] This set of differentials for North Carolina is significant at the 0.95 level.

[b] Results for livestock hours are not presented for North Carolina because livestock is a minor enterprise and the analysis is dominated by a few observations.

[c] This set of differentials for Iowa is significant at the 0.90 level.

[d] Adjusted total hours subtracts machine hire and hired labor hours and adds custom work performed by the farm operator.

[2] The same mathematical formula as was used in the actual payments was applied to information collected by the surveys. All components of income and expenses were included. The survey's estimate can also differ because of the accounting period. Actual payments used a one- or three-month averaging period with a twelve-month carryover procedure. Surveys did not collect information monthly, so the accounting period was simply a year with no carryover scheme. This could not have, particularly in the last two years of the experiment, accounted for some of the huge differences in actual versus predicted payments.

[3] Predicted payments were on the average $845 less in North Carolina and $676 less in Iowa than actual payments. The standard deviation of the differences was $845 and $1,030, respectively.

as the average percentage change for experimental farmers relative to the control group.

The operations with small amounts of fixed capital and operations, which could be adjusted easily from one year to the next, experienced the most disincentive. Observe the performance of livestock operations in Iowa and crop production in North Carolina versus that of the capital-intensive crop operations in Iowa. The former had a significant disincentive. Probably, the weakest aspect of this evidence is in the inconsistency in North Carolina between adjusted total hours (removing the effect of machine hire, hired labor, and adding custom work) and total hours. Payment farmers have an incentive to buy hired labor because the price has declined relative to control farmers; one would have expected the disincentive would increase when examining adjusted total hours.

The reporting variable was highly significant and positive in all budgeted hours equations except for adjusted total hours in North Carolina and crop hours in Iowa, where it was insignificant. In Iowa, percentage differentials, calculated at plus or minus one standard deviation of the reporting variable, range from 4% to 6%. The percentage disincentive was always less where the level of payment to farmers seemed to be in the greatest error. In North Carolina, the change was in the same direction and the range was 15%.

During the interviews, which were conducted once every three months, a question was asked about the number of hours worked by the respondent on his farm the previous week. No effort was made to have the respondents keep track of the number of hours worked on a day-to-day basis. By multiplying by 13 and summing over the four quarters in a year, a yearly estimate of recall hours worked could be made.

The chief disadvantage with "recall hours" is a Hawthorne-type effect, in this case, interpreted as a change in reporting behavior resulting from observation. For example, imagine respondents with low levels of education who suddenly begin receiving $1,500 a year. On each opportunity where contact is made with the benefactor, there is probably a tendency to convey an image of a hard-working and industrious individual. There might even be a feeling that the payments are somehow tied to their work effort (i.e., more money for more work), despite statements from project administrators to the contrary.

The experimental effects on farm recall hours are different from that of budgeted hours. The percentage differential is an insignificant, but positive, 4% to 7%. Simultaneous models used by Kerachsky and Evans employing annual recall hours showed a positive incentive of around 10%. In North Carolina, this difference was significant. The reporting variable was insignificant in all equations where the dependent variable is recall hours.

Farm Income

Farm income was also measured in two different ways: net and gross farm income. Net income refers to gross income minus total expenses during a designated time period, usually a year. Gross income is defined as all income during a time period minus the purchase amounts paid for cattle, hogs, or sheep that are sold during the designated time period. Expenses include fertilizer, crop insurance, interest, depreciation, and other similar expense items. Farmers had the option of electing straight-line or accelerated depreciation, consistent with their reporting to the Internal Revenue Service (IRS). In all cases, the net and gross farm incomes were to be on a cash rather than an accrual basis.

From a policy viewpoint, net farm income may be the appropriate variable. This measures a family's ability to attain a decent standard of living. If through the experiment this variable has a treatment effect, it could have substantial cost implications for a national negative income tax program. However, gross and net incomes are influenced by the timing of income and expenses. An experimental farmer has a strong incentive to build inventories of grain and livestock and pay expenses immediately, while delaying the receipt of income. In this way, his payment would be maximized. A farmer with access to credit would not have much difficulty in paying expenses immediately and delaying income and, consequently, would show a larger disincentive for income than what actually occurred.

Reporting of income is probably affected by the experiment.[4] The amount of payments the families received is a direct function of the amount of income that the respondent reports.

[4] There was a significant difference between control and experimentals in reporting from farm records when answering the quarterly interviews with experimentals reporting more frequently from farm account records.

Consequently, an experimental individual has incentives to report all the expenses he can. Furthermore, he may incur expenses within the duration of the experiment that otherwise might be delayed. Examples of this would be major overhauls of tractors or building upkeep. Adjusting the period of analysis would be an attempt to overcome this problem.

If a disincentive in hours did occur, the reduction in hours would be expected in those enterprises where the marginal return to labor is the smallest. Thus, farm profit should decline by a smaller percentage than labor input. If an incentive in hours occurred, one could probably expect that, because of diminishing marginal returns, farm profit would increase, although less than the percentage increase in farm hours.

Again, the actual effect on farm profit is sensitive to the definition of farm profit and the model specification. When profit is defined as gross farm revenue minus variable costs or as the monetary returns to fixed inputs and to farmers' own labor, and the model is estimated in simultaneous equations framework using recall hours, the empirical analysis indicates that the experiment had negative effects upon profit (Evans). These effects are generally large—between 10% and 30%. Furthermore, the percentage effects in North Carolina tend to be larger than those in Iowa. However, the results for both regions are statistically significant at only marginal levels.

When profit is defined as gross farm revenue minus depreciation and variable costs, or as the monetary returns to farmers' own labor, and the equation is estimated as a reduced form controlling for preexperimental conditions, the experimental effect is still negative. However, in contrast to the earlier results, it is insignificant and smaller—between 7% and 10%. Gross farm income had similar results to that of farm profit.

For both results, the experimental effects on profit did not vary systematically or significantly with changes in the tax rate or guarantee. Furthermore, there were no distinct time trends associated with these effects. Generally, the results for farm profits were consistent with budgeted hours as opposed to recall hours.

The reporting variable was again positive and highly significant in the farm equations. The percentage differentials were different by 49% for returns to labor in North Carolina and 75% in Iowa calculated at minus versus plus one standard deviation of the reporting variable. The range in gross farm income was less: around 16% in North Carolina and 22% in Iowa.

Conclusion

The major hypothesis advanced is that work effort should decline with an introduction of an NIT scheme. The answer varies depending upon the variable being analyzed. If recall hours are chosen, one concludes that the experiment had no effect upon hours worked. On the other hand, if budgeted hours are used, the evidence is quite strong that the treatment did affect work hours in a significant negative direction.

An unequivocal answer is highly elusive. A measurement of hours worked for the farmer is the intersection between his labor demand and labor supply curves. It cannot be argued that recall hours represent the supply curve and budgeted hours a labor demand curve. Both variables attempt to measure the intersection of the two curves. To establish which is the better variable, one must determine which measurement technique is best. To argue that economic theory should determine which is correct because one agrees better with the theory is not an independent test of the theory and not a particularly useful way of doing empirical research. Obviously, however, the variable that is judged best by independent criteria, statistical methodology, or whatever will hopefully correspond best to theoretical predictions.

Recall hours are based solely upon a respondent's declaration of the number of hours worked the previous week including overhead hours, while budgeted hours depends directly upon numbers of acres of corn, acres of soybeans, hogs sold, cattle sold, etc. These latter numbers are more likely to be remembered because they influence all subsequent management decisions. This is not to say that there were no errors in the reporting of year-end numbers; but if and when changes to these quantities were needed, the changes could be documented and these changes were relatively small compared with changes in asset or income variables (Primus 1975).

A further argument can be advanced. Presume that one has a number of different productive activities that need to be summarized as one. One immediately thinks of constructing a

linear combination of these different activities. Those weights should represent labor coefficients from other studies. However, because individually most productive enterprises decrease (Saupe), although not always significantly in quantity with respect to treatment variables, all reasonable coefficient sets would show a negative treatment effect. Consequently, if recall hours and budgeted hours are to be reconciled, three possibilities arise. (*a*) A Hawthorne effect does exist and is responsible for the difference. (*b*) While the experimental families have reduced their farm work effort in terms of growing corn or raising pigs, they have increased the number of overhead hours. While this may be true, it certainly is not policy relevant that the farmer must now take five trips to town instead of the previous two to accomplish the same mission. (*c*) An accident of random sampling resulted in experimental families using more labor-intensive techniques of production. This hypothesis is essentially negated, however, when various functional forms of work effort in 1969 (the preexperimental year) are entered in the model.

The results for budgeted hours are roughly consistent with net and gross farm income. Particularly, this is true when a measurement variable (actual negative income payments minus predicted negative income tax payments based upon edited quarterly data) is added to the model. Those families where actual payments exceeded predicted payments by a large amount are affected less by the program parameters (tax and guarantee rates) than families where actual payments equals predicted payments. Consequently, there is more disincentive in families where the latter occurred in terms of hours and income. The fact that the reporting variable was significant in the budgeted hours equation and not the recall hours equation strengthens the case that the budgeted hours are the better measure of farm work effort.

While there remains several disturbing aspects of the data, it seems clear that farm families reduced their crop hours significantly in North Carolina and their livestock hours in Iowa. The overall effect of an NIT on total hours is negative, significant, and on the order of 6% to 13%.

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Labor Supply Decisions of Farm Families

Stuart H. Kerachsky

Faced with changing economic opportunities, farm operators have increasingly been dividing their work time between self-employed farm work and the wage labor market—a situation that can be best described as multiple labor market participation. By 1969, the year in which the Rural Income Maintenance Experiment (RIME) began, over 54% of all farm operators in the United States had off-farm sources of income, primarily from wage work (U.S. Dep. Commerce). This figure had risen almost ten percentage points since the end of the previous decade.

Wage market participation rates of the two samples in the RIME are quite similar to the national averages for farm operators with the respective levels of farm sales. Over 33% of the experiment's Iowa farm operators and 58% of the North Carolina operators held wage jobs at some time during the three experimental years. When the labor market activities of both husbands and wives are considered, in almost 50% of the Iowa farm families and 78% of the North Carolina families either the farm operator, his wife, or both held wage jobs. However, wage work provided only a secondary source of income: for families participating in both labor markets, only about 23% of all earned income in Iowa and 48% of that in North Carolina derived from wage work.

These figures for the labor market activities of farm families clearly indicate that a study of their labor supply should focus on both the self-employment and the wage labor markets. Thus, this study analyzes the effects that an experimental negative income tax (NIT) program would have on farm family labor supply given multiple labor market opportunities. Theoretical considerations related to the study are presented, followed by a summary of the actual analysis. The final section of this paper discusses the main findings and places them in the perspective of the overall farm-related analysis conducted as part of the evaluation of the RIME.

Stuart H. Kerachsky is a senior economist with Mathematica Policy Research, Inc., Princeton, New Jersey.

This paper is drawn from the analysis the author performed for the Rural Income Maintenance Experiment as a project assistant with the Institute for Research on Poverty (Kerachsky). His contribution in the RIME final report provides a complete discussion of the theoretical and empirical work summarized in this paper.

Theoretical Overview

In a purely hypothetical world in which a farm operator is paid the value of his marginal product, receives no nonpecuniary benefits or costs from his work activities, faces no market imperfections or institutional constraints, and is not dependent on the labor market activities of other family members, a simple theory underlies multiple labor market participation (Lee): a worker will allocate his labor in a manner that maximizes the value of the marginal product of each hour worked. As a self-employed farm worker, he receives the full value of the marginal product (*VMP*) of each hour worked. As with other resources in the farm production process, the marginal return to labor is a declining function of the quantity used, *ceteris paribus*. In the wage market, on the other hand, labor is paid a constant hourly return (w) in the relevant range.

This distinction between the two markets suggests a particular utility-maximizing ordering of time allocation: as long as *VMP* exceeds w, the individual allocates work hours to the farm, thereby depressing *VMP*. At the point at which *VMP* falls to equal w, he channels his remaining work effort to the wage market, stopping all work when the marginal rate of substitution of income for leisure ($MRS_{l,y}$) reaches w (and *VMP*). Of course, corner solutions in which *VMP* equals $MRS_{l,y}$ at values greater than w are also common. In such cases, farm operators maximize utility by stopping work before they enter the wage market.

According to this simple theory, any change in income that treats the return to labor in each market exactly the same leaves the quantity of farm work unaffected. This result is particularly important for predicting the effects of introducing an NIT program. The income guarantee provision (G) of an NIT program does not alter the return to farm or wage labor at all, while the tax rate (t) alters each return equally. The new equilibrium condition between labor markets, $(1 - t)VMP = (1 - t)w$, implies switching from farm to wage work at exactly the same number of farm hours as before the introduction of the tax. In this case, changes in time allocation result only from changes in the wage-work/leisure equilibrium point, which is dictated by the equality of w and $MRS_{l\cdot y}$. Since w and $MRS_{l\cdot y}$ are altered differently by the provisions of the NIT program, equilibrium can be restored only by reductions in wage work. Of course, if all wage work is exhausted before equilibrium is restored, the residual adjustment occurs as a decrease in farm work. Finally, if the corner solution with no wage work exists, the full burden of restoring the equilibrium rests in reducing farm work.

The conclusion is that the impact of an NIT program on an individual's multiple labor market participation can be discerned if the analysis is confined solely to wage market participation, unless a corner solution is reached. However, this "conclusion" is merely a testable hypothesis and not one that can be defended without prior analysis. The possibility that nonincome utility differences and differential imperfections between the labor markets exist suggests a need for a more general theory.

Nonincome utility differences between farm and wage work are directly associated with the tasks an individual must perform on the farm or at his wage job and with his actual or perceived roles in the job settings. It is commonly believed that farm operators prefer farm work for reasons over and above the income it produces. There is the mystique that farmers have a "love for the soil" and that self-employed persons dislike determined work schedules and supervision. Restructuring the analysis so that the utility-maximizing framework reflects potential utility differences between labor markets leads to the following equilibrium condition:

$$VMP + d = w = MRS_{l\cdot y} - MRS_{wh\cdot y},$$

where d, which reflects the difference in marginal returns resulting from worker preferences, is the difference between the marginal rate of substitution of income for farm work ($MRS_{fh\cdot y}$) and of income for wage work ($MRS_{wh\cdot y}$). If d is positive, operators' utility-maximizing mix of work should include enough farm work to drive VMP below w.

Differential market imperfections can take many different forms. First, tax rules, both experimental and nonexperimental, provide workers with the ability to manipulate, legitimately or illegitimately, self-employment income to their own advantage. Workers may transform such income into a form treated preferentially by the tax laws; they may defer income or expenses to a more opportune time; or they may simply misreport income and expenses. Second, constraints on work schedules can prevent complete hours adjustments. In addition to the usual institutional constraints associated with the length of a wage work day, farm operators are limited with respect to which parts of the day or year they can spend off their farms. Finally, long-term investment activities may inhibit short-run job market adjustments. Such activities are usually associated with the farm, and they may increase farm work above the equilibrium level dictated by the simple theory. However, investment activities could also be associated with careers in the wage market, so they may increase wage work and decrease farm work from the equilibrium level of the simple theory. These examples of market imperfections are consistent with the general theory.

The general theory implies that the ordering of time allocation discussed in conjunction with the simple theory cannot be accepted as a general description of such labor market decisions. Certainly, it cannot be assumed that the guarantee and tax provisions of an NIT program will not affect the level of farm work. Furthermore, labor market decisions may be simultaneously determined, since they may well vary with such factors as the level of farm work, the level of wage work, the ratio of the two, and the level of nonwork income. Since work of any type is usually assumed to be an inferior good, a net decrease in work effort may still be expected. However, the source of this decrease is uncertain. On the basis of the above discussion, the level of farm work may increase for experimentals relative to controls, while the levels of both wage work and total

work decline. Of course, other scenarios are also possible.

This entire situation is further complicated by potentially interdependent labor market decisions among family members. As has been demonstrated (Killingsworth, Kerachsky and Mallar), such interdependence makes the theoretical effects of an NIT on a given member ambiguous.

The Analysis

Due to the theoretical ambiguities, the empirical investigation follows an approach that imposes few restrictions on the estimation of experimental NIT effects. The analysis is based on a four-equation simultaneous system. The three central equations are labor supply equations for the farm operators' farm work, their wage work, and their wives' wage work. (Wives' farm work and other family members' work are assumed to be associated with this system in a recursive manner.) To ensure consistent estimates of experimental effects, the nonexperimental portions of the equations are fully specified, including variables for the marginal return to work, income, life cycle and other demographic characteristics, and the work effort and marginal returns to work associated with participation in the other labor market and the labor market participation of the spouse. The portions of the equations that are designed to capture the effects of the experiment were variously specified as simple experimental status variables and complex interactions of status with demographic characteristics. The fourth equation in the system is a farm labor demand equation that, together with the endogenous marginal return to farm work variable, completes the system. Since the experimental NIT program is not expected to alter the farm production function, there is no experimental component of this equation; therefore, it is not discussed further in this paper.

The ease with which individuals may enter the wage market necessitates that the sample relevant to this evaluation include all farm operators and their wives. However, in both the farm and wage markets, differences exist among age groups, which suggests that these groups be analyzed separately. Because of the small number of young and old sample members, the analysis is confined to the middle-aged group—families in which the head was between 30 and 59 years of age at the start of the experiment.

Additional differences are evident between the North Carolina and Iowa samples. These are associated with farm enterprises and practices, the nature of the wage market, and the stocks of human capital. Consequently, the samples in the two regions exhibit different structural relationships, and they are analyzed individually.

The final samples are three-year panels of nearly 100 families in each region, approximately half of which are distributed among the five NIT plans. An error-components model is used to pool the three annual observations on each family, thereby increasing the effective sample size.

Since not all farm families contained members who participated in wage work, the analysis is divided into two parts. In the first, the annual hours of operators' farm work are evaluated together with the decision of the operators and their wives to enter the wage market. (Annual hours of farm work are constructed from the four one-week observations of hours recorded for each year. The binary wage work variables are derived from individuals' recall of wage work activities for entire quarters.) The second part of the analysis includes only those families in which at least one spouse participated in the wage market, and it evaluates the hours of farm work together with the hours of operators' and wives' wage work. Further refinement of this conditional concept would require a larger sample. While the estimation of equations with binary and bounded conditional dependent variables could be improved with appropriate maximum likelihood techniques, the complications of pooling and simultaneity require that a least squares technique be used.

Several versions of the labor supply equations were estimated with different specifications of both the nonexperimental and the experimental portions of the model. Both parts tend to support the general theory of simultaneous labor market decision making. In the nonexperimental portion, the support is evident in the cross-price and direct-work effects. In the experimental portion, the support can be inferred from the overall patterns of effects, as well as from the relationship between the structural and reduced-form estimates.

The average annual experimental effects on farm operators' and wives' labor supply are presented in table 1. These are calculated from

Table 1. Average Annual Experimental Effects on Farm Family Labor Supply

	North Carolina		Iowa	
	Absolute Differentials[a]	Percentage Differentials[b]	Absolute Differentials[a]	Percentage Differentials[b]
Farm operators				
Hours of farm work	186	13.8	141	5.9
Hours of wage work[c]	−258	−35.1	559	204.5
Employment in wage work	0.011	1.8	0.099	34.2
Total hours of work	−72	−3.5	700	26.3
Wives				
Hours of wage work[c]	72	5.2	−27	−73.3
Employment in wage work	−0.024	−3.9	0.054	17.5
Farm operators and wives				
Total hours of work	0	0	673	24.9

[a] These differentials are calculated as the adjusted experimental group mean minus the adjusted control group mean. Adjusted means are derived from the full sets of regression results and the average sample characteristics. The differentials directly reflect the effect on a "typical" sample member enrolled in the median experimental plan.
[b] These differentials are the percentage change from the adjusted control group mean to the adjusted experimental group mean.
[c] These figures represent changes in employment, as well as in hours of work conditional on employment.

the primary equations without regard to statistical significance. The effects for North Carolina form a reasonable pattern. The trend for farm operators is toward more farm work and less wage work, while for wives it is less pronounced. In all cases, the first year is characterized by generally insignificant effects that counter these trends. Only the underlying coefficient estimates for farm work and wives' wage work show patterns of statistical significance at the 0.10 level or less. The effects on wives' wage hours are the only ones that respond dramatically to changes in the other categories of labor supply: when the indirect experimental effects that operate through operators' farm and wage work are constrained to zero, the average direct effect on wives' hours is strongly negative. While there are strong patterns of experimental effects on individual family members' labor supply, the average effect of the median NIT plan on total family labor supply is zero. Finally, while the average effect on the farm hours of multiple market participants is not summarized in table 1, it is virtually identical to that for the entire farm sample.

The results for Iowa, also summarized in table 1, seem less reasonable at first glance. The only experimentally induced disincentive that is evident is on wives' wage hours, and while it is large in percentage terms, working wives in the Iowa sample report very few hours. The effects on farm operators' farm and wage work are positive, and those on the latter are particularly large and significant. However, two observations help place these results in a better perspective. First, the positive wage effects generally diminish over time. So, as with the North Carolina results, there is evidence that the first year reflects an adjustment to the new program rather than a longer term, normal response. Second, the large positive effects on wage hours result from the indirect effects of changes in farm hours and wives' wage hours. In fact, the average direct effect on operators' wage hours is negative. Thus, while the overall pattern is unusual, it is consistent with the generalized theories of multiple labor market participation and family labor supply. Once again, the average effect on multiple market participants' farm hours is very similar to that for the entire farm sample.

The small number of observations in most nonmedian plans suggests that the estimated effects of changes in the NIT parameters may be unreliable. However, interesting results do emerge. Changes in the tax rate produce no pattern of effects. This is consistent with the standard theory, since such changes should result in conflicting substitution and income effects. Changes in the guarantee, on the other hand, produce a pattern of negative and often significant effects. Again, this is consistent with the theory, since only an unambiguous income effect is produced.

Conclusion

It is important to determine what these results mean and how they fit into the overall pattern of farm-related experimental effects. Because

of the constant hourly return to wage work, the changes in such work can be translated directly into family income and, therefore, families' contributions to their own welfare. However, changes in self-employed farm work cannot be directly translated.

The most direct way to determine the farm-related effects of the experiment on family welfare is to analyze farm profit. The experimentally induced increase in farm work is accompanied by a decrease in profit of 15% to 17% in both regions (Evans). While some of this decrease probably results from the incentive of experimental farm operators to misreport profit and income, the magnitude of the effects and the strong time trends leave little doubt that there is indeed some decrease in profit. Farm-related experimental effects apparently did not improve family welfare and probably reduced it. Together with the wage work results, this implies a certain reduction in families' contributions to their own welfare in North Carolina and an ambiguous effect in Iowa.

One apparent paradox remains: how can the farm hours results be reconciled with the profit results? In his study of profit and hours, Evans also explored the concept of work effort, which reflects managerial ability and the intensity of activity (Leibenstein). He estimates that experimental and control farm operators are equally price efficient (i.e., they are equally profit maximizing in their use of variable farm inputs), but that experimental operators are less technically efficient (i.e., they produce less output from a given bundle of inputs). Consequently, while experimental operators spend more time on their farms, they become less careful managers. A more optimistic view is that these operators may devote time to farm improvements and other investment activities that may increase production and profit in the long run, while having unfavorable effects in the short run. However, there is very limited evidence that the latter may be the case.

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Discussion

Wallace E. Huffman

The income maintenance experiments have been unique in terms of public policy development. Prior to the development of new legislation on income-conditioned transfers, Congress was willing to fund an experimental version of such a program, including the analysis of behavioral changes induced by the experiment. The primary reason is the divergence of opinion about the impact on hours of work and earned income of household members covered by such a plan.

The inclusion of a rural experiment in the group of income maintenance experiments has meant that poor rural people have not been forgotten in the planning of new welfare legislation. Also, it has provided an opportunity to develop administrative procedures for handling problems that are somewhat unique to rural areas—a large proportion of self-employed persons and rather thin asset markets. These problems seem manageable.

Given that the primary objective of the experiment was to determine the effect on hours of work, I am puzzled about the small amount of resources that were allocated to obtaining data on the hours of farm work by farm family members. Weekly hours of farm work over a year by farm operators, by their wives, and by other farm household members have a relatively large variance compared with weekly hours by wage workers. Part of this variation is seasonal, but much of it is intraseasonal. Drawing upon experimental design theory, one quickly recognizes that the estimate of mean weekly hours for a quarter based upon a sample size of one has a large sampling error. Thus, one need not fall back on defects of the respondents, as Primus does in suggesting a Hawthorne-type effect, to be skeptical of levels and differences in reported hours of farm work by farm household members.[1] These measurement-error problems with reported hours have undermined much of the empirical analysis that was oriented toward the primary objective of the experiment, including the research reported by Primus and Kerachsky.[2]

The research methodology employed in the three empirical papers troubles me as an economist and an empirical researcher. As scholars, we must carefully blend economic theory and econometric techniques in our data analysis in order to advance knowledge and understanding of systematic social behavior, but the path to this end is not always well marked.

I have three major concerns. First, some empirical relationships reported have weak foundations in economic theory. It may be an interesting question as to how experimental and control farm households differ in their crop and livestock inventory holding (sales) patterns, debt-to-asset ratios, sources of credit, etc., but I see no convincing reasoning behind the so-called control variables included in the analysis or behind the empirical specification of the basic issue. For example, rather than looking at size of farm sales, why not investigate differences in the ratio of farm sales from current production? A negative income tax may give low-income household greater flexibility in the timing of their marketing of products, i.e., lead to an increase in the expected price of farm output and farm profit. Furthermore, the number of explanatory variables in such a regression would be small, and observations might be homogeneous across states. Also, how do experimental and control farmers differ in the ratio of current expenses to the total value of farm production? If low-income farmers are faced with serious credit rationing, a negative income tax program may ease their credit constraint and effectively lower the price of purchased inputs. In addition, a key indicator of a farmer's level of

Wallace E. Huffman is an assistant professor of economics, Iowa State University.

The papers discussed are a very brief summary of much larger chapters of the final report of the Negative Income Tax Experiment. The discussion focuses mainly on the papers. Journal Paper No. J-8938 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 2078.

[1] In addition, there could be a Hawthorne-type effect.

[2] The seriousness of measurement errors does depend on whether reported hours are right-hand or left-hand-side variables in the regression analysis and whether they are correlated with other included variables.

management is the quality of his farm business records. Did the experiment cause experimental families to keep better farm business records than control farm families? Primus' paper, rather than Saupe's, suggests that the answer is yes. If so, this would be a significant finding of the negative income tax experiment, and it has important implications for improving the management of farms operated by these low-income families.

A second concern is that the implications from economic theory about the expected behavior induced by the negative income tax experiment are sometimes not carefully drawn or stated. A household constrained utility maximization model, where household members obtain satisfaction from their leisure time (or "nonwork" time) and a composite market good and allocate their human time between work and leisure, does not lead to an unambiguous prediction of a reduction in hours of work as a result of the incentives of a negative income tax. Consider the case of a household with a single worker. The tax on earned income of a negative income tax plan causes a pure substitution effect toward more hours of leisure by the worker and fewer hours of work, but the predicted change of hours of work from the pure rise in real income of the tax-guarantee combination is ambiguous (Rees). It depends on the sign (and size) of the income elasticity for his leisure. Empirical estimates of the income elasticity for leisure, not theory, are the only guide here. Thus, a negative work incentive effect is unambiguous in a one-worker household only if empirical estimates of the income elasticity for the worker's leisure is nonnegative.[3]

In addition, implications from economic theory have not been fully exploited as a guide for obtaining the variables for explaining hours of off-farm work. Consider the introduction of a negative income tax plan and assume that farm household's maximize utility subject to an endogenously determined income-expenditure constraint, human time constraint, and farm production function constraint. In this model, the household simultaneously determines the quantity of goods and human time or leisure consumed, the hours of off-farm work, the quantity of farm inputs, including the hours of farm work, and the quantity of farm output. The point is the simultaneous determination of the hours of off-farm work and the inputs into farm production (and also farm output). Furthermore, the quantity of off-farm work supplied is the difference between the total supply of work at each implicit wage and the demand for farm work. The quantity of farm work demanded depends on the prices of the variable inputs and prices of farm outputs and on a few truly exogenous factors, but it does not depend on variable input quantities. Few inputs are truly fixed, even land. There is a rental market for land services that is active. Thus, too many variable inputs are right-hand-side variables in Kerachsky's and Primus' analyses of work effect. For an analysis of off-farm work, I suggest that predicted farm output and available prices be used instead of these variables. This change in model specification would also economize on degrees of freedom.

Also, Kerachsky makes a major issue of the fact that reported hours of farm work of experimental household members do not behave according to predictions from a simple work-leisure model of time allocation, so he introduces nonmonetary aspects of working time to get around this problem.[4] I suggest that the total effect of a negative income tax payment may be more pervasive than his simple model permits and that nonmonetary aspects of work need not be introduced to explain a change in hours of farm work.[5] Consider that farmers make production decisions based upon expected farm output prices rather than on actual prices and that negative income tax payments give a farm household a wider range of dates for marketing its farm production, i.e., it causes the expected price of output to be larger than otherwise. This added effect of a negative income tax payment is sufficient to cause hours of farm work correctly measured to change (to increase) as a result of the experiment. There are, of course, other examples that can be hypothesized.[6]

[3] If the estimate of the income elasticity is negative, then an empirical estimate of the size of pure substitution effect is also required before an unambiguous statement about the effect of a negative income tax plan on work incentives can be made. If the labor supply model is further complicated so that there are two workers in the household, the expected effect of the incentives of a negative income tax plan on either worker's hours of work becomes more uncertain and requires empirical estimates of more parameters.

[4] Given the measurement errors in reported hours of farm work, true hours of farm work may be unchanged.

[5] Nonmonetary aspects of work are difficult to measure. Furthermore, differences in hours of farm work between experimental and control households must be due to price and income effects on these unmeasured characteristics of working time.

[6] Saupe's paper and other studies of the rural negative income tax data have also looked at issues that may cause hours of farm work to change.

A third concern is that the empirical models reported give too much emphasis on diversity of response between Iowa and North Carolina households and not enough emphasis on building models applicable over the whole sample of households, or at least over some groups consisting of observations from both states. It was argued that there was too much diversity across states to pool observations. This lack of uniformity of response has quite undesirable implications when one considers a universal negative income tax.

A scholar has the obligation of finding a systematic response in seeming diversity. Furthermore, I think that the challenge is not too great. It may, however, require reformulation of the models to be estimated. Bryant reports on one such successful attempt with the data from the negative income tax experiment.

Modern econometric techniques provide methods for pooling observations even when some response coefficients differ across groups. Pooling all the relevant observations also increases the degrees of freedom and generally increases the variation in the variables. Both of these characteristics are important for those who expect to find statistically significant relationships. A search of the literature shows that at least 200 to 300 micro observations are generally required before important explanatory variables in a relationship can be expected to consistently have t-values that generate excitement. The research reported above has paid a price in the form of small t-values for the ways the models were built.

The initial round of analysis of the data for the farm households from the negative income tax experiment has provided fewer conclusive results than one would like. But perhaps behavioral changes were small, and we expected too much. Later analysis with more comprehensive models may uncover more results. The results of the initial analysis do suggest that any work disincentive effects are generally small for farm household members. Thus, a major welfare reform based upon some type of negative income tax continues to be a promising goal.

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Welfare Implications of Extended U.S. Fisheries Jurisdiction
(Virgil J. Norton, University of Rhode Island, Chairperson)

Constraints to Welfare Gains under Extended Jurisdiction Fisheries Management

Daniel D. Huppert

The recent extension of the U.S. fishery conservation zone to 200 miles and the adoption of economic objectives for fisheries management in this zone make the consideration of welfare gains an important current issue. The economic objectives contained in the Fishery Conservation and Management Act of 1976 (FCMA) are especially noteworthy. It has been well established in both theory and practice that economic gains will not necessarily result from fishery management geared to the traditional biological objectives such as maximum sustainable physical yield (MSY). The maximization of social welfare requires the explicit consideration of economic values generated by fisheries, the private and social costs of exploiting and managing the fisheries, and the probable distribution of income resulting from fishery regulations. In addition, theoretical economic analyses must be tailored to statutory requirements and political necessities before economically sensible fisheries management will be achieved. To assure that this administrative and political process results in the realization of potential economic gains will be a long-term task for fisheries economists and administrators.

The received body of theory in fishery economics emphasizes the importance of free access to fisheries as a source of welfare loss. The theoretical argument has changed little since the publication of Gordon's seminal article in 1954. Gordon argues that a competitive industry exploiting a common property fish stock will grow until all potential net economic return (or rental value of the stock) is dissipated. Fishing vessels that are privately maximizing their own profits will fail to respond to the social costs of depleting the resource and, as a group, will deplete the fish stock until the average cost of production rises to equal the market price of the fish. If the rate of fishing were lower than the competitive equilibrium rate, the fish stock would be more abundant and the cost of production per ton of fish would be lower. The ideal economic solution to the common property (or "externality") problem requires that the investment of capital and labor in the fishery be prevented beyond the point where incremental costs are justified by marginal social returns. There are a variety of institutional arrangements that could facilitate the achievement of the economically efficient production pattern, including administrative allocation of fishing licenses, fixed price license sales, fishing license auctions, landings taxes, assignment of individual quotas to fishermen, and undoubtedly others (Christy).

The static economic efficiency theory has been extended to incorporate dynamic efficiency criteria by, for example, Brown and Clark. Also, numerous case studies have applied variations of Gordon's theory to real fishery situations and have uniformly found that efficient economic exploitation of fish stocks entails the maintenance of larger fish populations and smaller fishing fleets than would be achieved under free access competition (see, for example, Crutchfield and Zellner, Crutchfield and Pontecorvo, Gates and Norton, Huppert, or Bell). By maintaining smaller fishing fleets and larger average fish stock abundances, an efficient economic man-

Daniel D. Huppert is with the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, California.

agement system would provide more real income to the nation than would either free competition or management for maximum physical yield.

Christy suggests that the total amount of economic yield lost through free access competition in the U.S. fisheries is on the order of $300 million annually. At 6% annual interest, the capitalized value of the lost economic yield is about $5 billion. This represents an impressive potential gain in real national income and should provide an incentive for greater efforts to achieve economic efficiency in fisheries.

Some Income Distribution Aspects

The body of traditional literature on fishery economics clearly emphasizes the inefficiency of free competition for fishery resources and prescribes economically efficient rates of exploitation. To a large extent, the policy prescriptions of received theory rely upon an implicit assumption that the group or groups subject to the welfare arguments are well defined. In actual fact, there are several stances that might be taken in defining the constituent group. Each definition carries with it a different set of conclusions for U.S. policy. Three possible accounting frameworks that come immediately to mind are (*a*) the group of existing participants in U.S. fisheries, i.e., the domestic fishermen; (*b*) the domestic populace as a whole, dominated by consumer interests; and (*c*) the world population. Clearly, the fishery management policies that would be adopted to benefit the existing domestic fishermen most would differ from the policies that most benefit the aggregate of domestic and foreign fishermen or that serve the population of the United States at the expense of foreign consumers and fishermen.

Although an interesting discussion could focus on the relative deservingness of foreign versus domestic interests, the FCMA is obviously intended to place U.S. citizens in a privileged position. However, maximizing domestic benefits from fishery resources in the Fishery Conservation Zone is not synonymous with developing a solely domestic fishery. Not only are some of the heavily exploited fishery resources presently utilized mainly by foreigners (such as Pacific hake and Alaska pollack) but it may well be that sunk investments in substantial vessel capacity coupled with lower wage rates make foreign exploitation an economically desirable alternative to development of domestic capacity.

Explicit economic cooperation is a growing possibility. Joint fishing arrangements between foreign interests and U.S. domestic companies are already beginning to appear. These arrangements take two forms: the foreign processing vessels plan to buy fresh fish from U.S. fishing vessels, and foreign companies invest directly in U.S. companies for the purpose of assuring a future supply of fish. In either case, the flow of fish from the U.S. zone to the foreign nation may proceed despite the declaration of exclusive fisheries jurisdiction by the United States. The United States can still benefit from the fishery harvests by harvesting and selling the fish, by participating in a joint venture to harvest and process the fish on U.S. soil before shipping to a foreign nation, or by simply charging a fair price for the foreign harvests.

Domestically, the welfare gain estimated by Christy could be distributed in a number of ways. If existing participants are freely given property rights to the annual yields of the domestic fish stocks and the exploitation of these stocks is rationalized through limited entry programs, the gain could accrue solely to the aggregate of fishermen. If, on the other hand, the marginal social value of the fish stocks is extracted from fishermen through taxes or license fees, the net economic value of fisheries could accrue through the public treasury to the U.S. populace as a whole. Innumerable combinations of fees and licensing arrangements could be devised to distribute any proportion of the potential economic value to both the fishermen specifically and to the public generally. In any case, the realization of the potential economic value is predicated on a reorganization of existing institutions. Such reorganization removes the long-observed right of all citizens to fish commercially and replaces it with a conditional permit to fish bestowed upon the chosen fishermen by the federal authorities. Regardless of how this transformation is engineered, some fishermen are bound to be excluded from traditional fisheries in order to allow the remaining participants (or the general public) to enjoy the fruits of economic efficiency. A measurable increase in net income to some existing and all future participants may not be socially desirable, however, if it is accomplished only at the cost of impoverishing some segment of the existing fishery or eliminating potential future

income of yet unborn fishermen. Thus, the existing economic structure may combine with official reluctance to deal with difficult distributional issues and prevent the development of institutional arrangements that allow net economic benefit to be enjoyed from the nation's fisheries.

Potential Barriers to Welfare Gains

Because the FCMA provides the most important new set of institutions in the domestic fishery arena, most of my comments will focus on it. Nevertheless, the new fishery management councils and the Secretary of Commerce's authority to promulgate new fishery management regulations must be viewed as an additional layer of federal jurisdiction imposed upon established state/local and international institutions. States retain fishery management authority within their boundaries (i.e., within 3 miles of shore), and highly migratory species of fish, primarily tunas, remain within the institutional framework of international fishery management agreements. Also, many of the important species of fish exploited by U.S. fisheries do not obey the artificial political boundaries of the Fishery Conservation Zone. On the West Coast, transboundary stocks include the several species of salmon in the Pacific Northwest, the northern anchovy stock, and several commercially and recreationally important pelagic fish stocks. In the New England region, the major demersal fish stocks range significantly into the Canadian fishery zone. Superficially, the FCMA appears to create the mythical "sole owner" envisioned by Scott and other economic theorists, but in reality the federal authority created by the Act is but one of two or more authorities now claiming some management rights to many of the fish stocks important to the U.S. fishing industry.

The lack of comprehensive, unified management authority and the resulting possibility for counterproductive jurisdictional disputes can be identified as a significant institutional factor constraining the potential achievement of economic efficiency in U.S. fisheries. Disputes between state and federal authorities are likely to be of relatively minor significance due to the preeminence of the federal authority (sec. 306, FCMA). This is not to say that differences of opinion will be rare but only that the ability of the Secretary of Commerce to overrule state management regulations within state waters should be sufficient to prevent any substantial economic losses through inadequate management control in fisheries occurring both within state waters and the Fishery Conservation Zone.

In the international arena, of course, there is no similar superior authority. Ideally, the independent nations participating in a given fishery would reach agreement upon optimal management measures and would subsequently share in the economic benefits of efficient exploitation. In most cases, such agreement would probably have to rest upon improvements in the welfare of each participating nation. Crutchfield notes that most major international fisheries in the North Atlantic and North Pacific involve sufficient waste that rational management could provide adequate welfare gains to a large number of participating nations. Nevertheless, the institutions for implementing international management authority, even with unanimous agreement about its desirability, are either nonexistent or poorly organized in important cases. Also, it is unfortunately true that some nations may choose to engage in strategic behavior designed to gain them greater shares of the world's resources in the long run, rather than to join international agreements that tend to reinforce existing shares as a compromise position.

Although some nations may find unilateral or multilateral agreements beneficial even without full participation by all nations involved in the fishery, economic theory suggests that such actions may be disadvantageous. According to Anderson, if one nation reduces fishing effort in order to approach a unilateral optimum fishing level, there is an automatic incentive for other nations to increase their rates of fishing. It is even possible that the resulting decrease in available fish to the original nation could be of sufficient size that in the new international equilibrium the nation loses economically (Anderson). Under such circumstances, international cooperation would appear to be an all-or-nothing proposition. On the other hand, most shared fisheries important to the United States may be sufficiently controllable unilaterally to allow the achievement of some welfare gains without full international cooperation.

Some specific provisions of the FCMA and current implementing regulations may also act to retard progress towards economic

efficiency. The FCMA specifically prohibits the Secretary of Commerce from collecting from domestic fishermen fees that exceed the administrative costs incurred in issuing permits to fish. This provision effectively bars any limited access program attempting to restrict fishing effort through imposition of user charges or attempting to extract some of the net economic yield from the fishing industry for support of scientific research, management costs, or general budget items. Without charging fees sufficiently high to extract rent or discourage excessive investments, a limited access program can still be implemented and can result in substantial economic efficiency benefits. But the distribution of the benefits is a rather nonnegotiable matter; the fishermen (or the owners of permits to fish, if not fishermen) will "get the swag." Depending on one's sense of distributive justice, this could be bad or good. But, as Christy observes, the general taxpayer will be footing the bill for research and management but not receiving any corresponding return from the public fishery resource, and the Office of Managenent and Budget may feel compelled to severely limit the funds for fisheries research and management.

The level of foreign fishing fees levied under the authority of section 204 of the FCMA is to be established by the Secretary of Commerce in consultation with the Secretary of State. The Act imposes no rigid limit on the fees charged to foreign interests, but the fees are to be reasonable and apply nondiscriminatorily to each nation. The fees adopted for the period starting 1 March 1977 include a permit fee of $1.00 per gross registered ton for each fishing vessel, $0.50 per gross registered ton for each processing vessel, and a flat $200 annual fee for each vessel assisting or aiding the fishing operation. Also, a poundage fee of 3.5% is levied against the exvessel value of the foreign harvests. As of 21 May 1977, nearly $10.3 million dollars had been collected from these fees—$785,087 in permit fees and $9.5 million in poundage fees. In adopting the fee schedule, the Department of Commerce decided not to use the fees as a management tool to restrict foreign fishing but did want to cover an appropriate part of the management costs related to foreign fishing. It was never made clear what the "appropriate part" of the costs were, but clearly the low poundage fee would not extract a significant portion of the total value of the foreign catch, estimated to be $271 million at 1977 prices.

The decision not to use the foreign fees as a management device or as a means to appropriate a significant part of the resource value has important ramifications. Under the constraint of minimal foreign fishing fees, the domestic optimization of fishery management may rely upon second-best measures, including an excessive emphasis on replacing foreign fleets with domestic fleets, even in those fisheries that are most efficiently prosecuted by foreign fleets. Also, some fisheries will continue to be dominated by foreign interests. In these, the combination of low fees and rationalized management could eventually result in a transfer of economic rents from the United States to foreign fishing firms. A theoretically sound fee structure would place a tax on harvests equal to marginal increase in fishing costs due to the reduction in fish stocks by harvesters (see Smith, p. 194, for example). While there may be compelling political and economic reasons for not charging such a tax to domestic fishermen, the extension of this policy to foreign interests will certainly reduce the welfare gains enjoyed by the U.S. citizens under extended jurisdiction fishery management.

Other possible constraints to the achievement of welfare gains arise from the regional orientation of the fishery councils and the makeup of the councils themselves. It seems highly probable that each Regional Fishery Management Council will tend to consider only regional income gains. Because the political and social, if not economic, importance of the regional fishing industry will loom larger than national concerns, a parochial view of management on the part of councils could easily lead to management plans aimed at improving the economic wealth of regional segments of the industry at the expense of the nation as a whole. Such a tendency could, for instance, be manifest in plans requiring tremendous inputs of research and administrative manpower, while requiring little or no restrictions on commercial fishing to improve efficiency and calling for no fees whatever to be paid by the beneficiaries of the plan.

Countering this tendency are the national objectives and standards of the FCMA. Specifically, the optimum yield of each fishery is to be defined such that the greatest overall benefit to the nation is served. Theoretically, such a yield is defined with a heavy weighting given to consumer interests, emphasizing larger sustainable supplies of fishery products and prices as low as possible under current

cost structures. Also, the national standards relating to efficiency and cost minimization, if vigorously enforced by the Secretary of Commerce, would constrain the ability of Regional Fishery Management Councils to act in a nationally nonbeneficial manner.

One additional observation on the likelihood of fishery management being focused on local, rather than national, interests is appropriate. By and large, the appointed membership of the councils is dominated by industry spokesmen and others having long-time connections with past fisheries management bodies. While this is only natural under the circumstances, the new economic objectives and initiatives called for under the FCMA may not come easily from such management bodies. Experienced fisheries scientists and administrative officials in the United States have generally been reluctant to tackle issues of income distribution and economic efficiency. To many, limited access is anathema on ideological grounds. Witness the "Alaska limit" purse seiner, the sail-powered clam dredge, the grossly overcapitalized Pacific Northwest salmon fisheries. Combine this with the pronounced tendency of labor unions to maintain employment above technologically necessary levels, and the general interest of established industry members to protect entrenched interests, and there may be substantial resistance to the adoption of measures that improve fishing efficiency and that sufficiently reduce or retard overcapitalization.

A final constraint to improved economic performance of fishery management is the woefully inadequate existing economic knowledge of recreational fisheries and the consequent lack of serviceable economic models and measurements addressing the trade-offs between recreational and commercial fisheries. On a theoretical plane, enjoyment of fishing as recreation has as much claim to the attention of economic analysis as the consumption of fish as a commercial product. As a practical matter, the marine recreational activities have a substantial economic value. It should be expected, therefore, that a significant source of national welfare gain would accrue from optimal treatment of recreational fisheries.

One reason for the dearth of economic studies on recreation is the difficulty encountered in applying traditional competitive market theory. The output in the recreational fishery is not satisfactorily valued at market prices. Economists have emphasized that recreationalists are not buying fish but are paying for an experience, one aspect of which is the capture and consumption of fish. A commonly espoused institution in recreational fishing is free access to the resource.

Lacking adequate price data, demand curves can be estimated by the travel cost method (see Brown, Singh, and Castle) or the direct interview method (see Meyer). The resulting estimates provide a means of valuing fishing trips but do not necessarily yield information pertaining to the marginal value of fish to anglers. Special efforts must be made to estimate marginal values so that recreational and commercial values can be converted to the same economic units.

Further confounding the ability of fishery managers to adequately balance recreational and commercial values is the fact that the optimal yield and optimum stock size may be radically different for a recreational fishery than for a commercial fishery. As noted by Radovich, recreational fishing may be best with fish stocks much closer to virgin levels than to the level required for maximum sustainable yield. To the extent that a high catch-per-angler day is a valuable aspect of recreation, any attempt to optimize a commercial fishery will be of detriment to recreation. Also, large "trophy" fish are more abundant in a large, older fish population. Finally, there is some evidence that recreational fish have a greater tendency to strike angler's baited hooks when fish populations are closer to maximum abundance.

On the assumption that management authorities will take quantified, commercial value as more important than unquantified, recreational values for fish, the lack of established, measured values of fish to the recreational sector could result in substantial misallocations of fishery resources, reducing the welfare gain achieved under extended jurisdiction fishery management. The responsibility for solving this problem rests squarely on the academic and government economists involved in fisheries. The evaluation of all fishery sectors is, after all, the job of the practicing economists.

Conclusions

The fact that several important constraints to welfare gains can be found in current institutions should not be received with overwhelming pessimism. Necessary, but not sufficient,

conditions for improved economic performance of U.S. fisheries are created by the passage of the Fishery Conservation and Management Act of 1976. Among these conditions are the establishment of federal authority over areas of sufficient breadth to allow unified management; creation of regional councils authorized to develop management plans with local industry cooperation as well as scientific advice; specific economic criteria for fishery management plans; and means to control foreign fishing harvests within the U.S. zone. Although there are some disturbing restrictions upon the use of economically desirable management tools (such as substantial fees or landings taxes on fishermen) and jurisdictional disputes could encourage economically inefficient fishery management plans, the success of the management effort to achieve economic welfare gains will depend more upon the actions and attitudes of the fishery councils and federal authorities than upon any rigid institutional constraints.

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Constraints to Welfare Gains under Extended Jurisdiction Fisheries Management: Discussion

Lee G. Anderson

Huppert has presented a good discussion of the constraints to welfare gains under extended jurisdiction fisheries management. While I certainly do not have any serious qualms with his presentation, one definitional point should be made at the outset. As used in the paper, at least as I interpret it, welfare gains really mean potential welfare gains or, more properly, the attainment of economic efficiency. In fact, phrases like "constraining the potential achievement of economic efficiency" and "retard progress toward economic efficiency" are used interchangeably with others like "constraints on the achievement of welfare gains." The former are superior in the context of this discussion because not achieving economic efficiency does not preclude welfare gains to at least some groups. In my comments I use the more straightforward term—economic efficiency.

Huppert began by making the very basic, but still quite often neglected, point that an unregulated fishery can result in economic inefficiency as well as biological depletion. He then touches on the distribution issue and points out that there are three possible accounting frameworks. In my view, the fishing industry, including harvesters, processors, etc., are receiving the most attention, as opposed to the nation as a whole or the rest of the world.

In his comments on using a worldwide accounting framework, Huppert touches on the issue of joint fishing arrangements between foreign interests and domestic companies. Depending upon the exact regulations concerning joint ventures that are promulgated, there may be serious problems in the interpretation of surplus yield (i.e., the difference between optimal yield, as defined in the law, and domestic capacity), and this may require some modification in the law. The distribution of the gains will depend critically upon the final resolution of this issue.

Five potential barriers to economic efficiency are discussed. They are (*a*) overlapping authority (from the different states below and other nations above); (*b*) certain provisions of the act, especially restrictions on the use of taxes as a regulation tool; (*c*) the regional orientation of the councils; (*d*) the industry domination of the councils; and (*e*) the inadequate knowledge of recreational fishing, which may cause it to be neglected in decision analysis.

I definitely think provisions exist in the act that retard progress toward achieving economic efficiency, one of which may be more serious than the constraint on the use of taxes. The provision that bothers me is national standard 5, which states: "Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose" (U.S. Congress, PL 94-265, sec. 301(a)(5)). If the last part was not included, this would be a useful national standard. However, if the term "economic allocation" is to be interpreted in the sense of an "efficient allocation of resources," the last phrase essentially negates the first one. Using this definition, this standard says that we should strive for economic efficiency except that we should not strive for economic efficiency. If this interpretation is used, the fact that taxes cannot be used becomes relatively unimportant. Not being able to use an economically useful regulation tool does not really matter if an economically rational management program is precluded.

If the term "economic allocation" is to be interpreted as distribution, the prospects for

Lee G. Anderson is an associate professor of economics and marine studies, University of Delaware.

economically rational management are not so bleak. I was hoping that, when the regulations for implementing the FCMA were distributed, the confusion would be settled. Unfortunately the results are mixed. In that part of the guidelines that are final, the section that expands upon National Standard #5 states:

> Economic efficiency may be regarded as one of many factors to be considered in the development of a plan. Councils will be involved in decisions about the distribution of costs and benefits, provision of employment opportunities, changes in the rate and composition of regional economic development, environmental effects, etc. To follow efficiency principles exclusively may not provide the greatest overall benefits to the nation or necessarily reduce costs to the consumer. Accordingly, both the advantages and disadvantages of "efficiency" will have to be carefully weighted in the context of the objectives for the particular fishery involved (*Federal Register* 1977a, p. 34459).

I find this satisfying. First, it says that economic efficiency may not be the only goal. However, this is not the same as saying it cannot be the main or central goal, making economic efficiency at least a possible candidate for a management objective. Of course, there can be some adverse distributional or other sociopolitical effects from following a strict economic efficiency policy, and there are certainly times when trade-offs between economic efficiency and other social goals may be desirable up to a point. This is allowed for according to the above guideline.

Further on in the same section of the guidelines we read: "Where conservation and management measures are recommended for economic allocation and for other purposes, due consideration shall be made of the biological, ecological, and social consequences of such measures" (*Federal Register* 1977a, p. 34459). The definition of "economic allocation" is still not clear (although phrases in the first quote such as "distribution of benefits and costs" may mean that it refers to distribution rather than efficiency), but at least the guidelines are not as strong, in a negative sense, as the standard itself. All it says is that consideration shall be given to other effects.

The problem of interpretation is made more difficult by the section of the guidelines in the *Code of Federal Regulations* that deals with the specifics of writing management plans, which, by the way, are only preliminary at the time of this writing:

> Any plan containing a limited entry system shall also discuss why other management measures are inadequate for conservation and management of the fishery. Limited access is a management technique that is directed at economic as well as biological objectives. This technique is used to reduce the congestion and economic waste that often occurs from the "open access" condition of common property fisheries. Any system of limited access shall be for the purpose of conservation and management, and economic allocation shall not be its sole purpose (*Federal Register* 1977b, p. 36983).

Here, the reference to the economic wastes that occur with open access may mean that economic allocation should be interpreted as in "efficient allocation of resources." In any event, a plain interpretation of the section would be as follows: limited access is a tool to eliminate economic waste, but it cannot be used solely for that purpose. This is somewhat contradictory to the passage quoted earlier, and I hope that, when the final version of the regulations are promulgated, this confusion is resolved.

Moving on to the point about the lack of recreational data, the problem is really one of a lack of adequate social and economic information in general. A casual reading of law makes it obvious that fisheries are to be managed to achieve social and economic objectives and not, as has been done in the past, for strict biological survival of the stocks. Given the nature of international fishing commissions, achieving biological survival was perhaps the best that could be hoped for. Now, with a central control, we are hoping for more. However, we have no counterpart to the biological information that has been collected for decades to aid in selecting strategies to achieve social and economic objectives. The problem of a lack of information is complicated by inertia. Most fisheries managers are used to thinking in biological terms, and it will be understandably difficult for them to expand their frame of reference when there is little data on which to rely.

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Constraints to Welfare Gains under Extended Jurisdiction Fisheries Management: Discussion

Richard Marasco

The Fisheries Conservation and Management Act of 1976 (FCMA) resulted in reclassification of a number of fish species that reside off U.S. coasts. Prior to existence of this Act, the United States could claim ownership to numerous species of fish only after capture. Resources of this type have been referred to as being "fugitive" (Ciriacy-Wantrup, p. 141). The FMCA has reduced these resources to common property of U.S. citizens.

The question that must be posed is, "Does the reclassification of fish off the coasts of the United States insure socially desirable usage?" The answer is no. As indicated by Huppert, the received body of theory in fishery economics emphasizes the importance of free access to fisheries as a source of welfare losses. Classification of fish resources located within the 200-mile zone as common property does, however, facilitate devising of regulatory systems that can be used to affect socially desirable usage.

It is in the examination of regulatory possibilities that constraints to welfare gains from fisheries management are brought into sharp focus. Fishery regulations may be classified into two categories, those affecting the size of fish caught and those affecting the total amount of fishing effort. Prohibition of fishing in nursery areas, seasonal closures, size limits, and gear limitations are examples of regulatory measures that can be used to control the size of fish caught. Regulations that influence fishing effort are area closures, gear restrictions, quotas, time closures, limitations on the number of boats, and various forms of taxes and licensing schemes.

Fishermen have historically opposed regulations that restrict effort. In situations where exploitation reduced the biological status of a fish stock to a depressed state, fishermen have supported regulatory measures that permit free access to the fishery such as gear and time restrictions. A question that might be asked is "Doesn't the state of Alaska's limited entry program provide an example of fishermen's support of effort limitations?" Elimination of non-Alaskan fishermen served as the catalyst that generated interest among Alaskan fishermen in entry limitations. Thus, support for the program did not stem from a concern over economic efficiency. Support instead was based on the desire to protect the economic position of a certain group of fishermen.

Fishermen's opposition to entry limitations coupled with industry's power within the current regional councils suggest that achievement of economic efficiency via entry limitations faces a difficult battle. Therefore, I share Huppert's concern over the makeup of the various regional fishery management councils. It is not clear that the current composition of the councils will facilate the adoption of positions that will lead to economically sound operation of the nation's fisheries.

The purpose of encouraging adoption of regulations that serve to foster sound operation of fisheries by the councils could be furthered by the development of more refined and realistic empirical bioeconomic models. The availability of data and the cost of data acquisition serve to hinder these efforts. Fish stocks exist in ecological systems where stock interrelationships and environmental conditions are extremely important. Salinity, temperature, prevailing currents, number, and feeding habits of other species of fish are known to be important environmental factors that influence stock growth rates. Collection of data that are required to determine the importance of various environmental factors on growth rates is costly but required if realistic models are to be developed.

Richard Marasco is an economist at the Northwest and Alaska Fisheries Center, Seattle, Washington.

Deficiencies also exist in the economic data base. In addition to the lack of knowledge associated with recreational use of fish identified by Huppert, numerous voids exist in the knowledge of the nature of food fish consumption. Only limited information is available on the degree of substitutability among species at the consumer level. It is generally believed that restaurant consumption accounts for in excess of 50% of all the food fish consumed in the United States. At present, hard data on the magnitude and determinants of restaurant consumption are nonexistent. Knowledge of foreign fish markets is also unsatisfactory. Sufficient information concerning the competitive atmosphere existing in the processing sector as well as capacity and costs are lacking. The current harvesting cost data base is erratic and in many cases out of date. Harvesting capacity in most fisheries is not known. Considerable fishing effort data exists; however, there are serious gaps. In general, the definition and measurement of fishing effort is a complex issue, and the most appropriate data elements vary between fisheries. While the above list of data deficiencies might be considered lengthy, it is not exhaustive. Data deficiencies when encountered retard the development of fishery management models. These inadequacies serve as constraints to the realization of welfare gains that could accrue from fisheries management.

An examination of constraints to welfare gains is incomplete if the issue of cost of instituting and enforcing regulatory measures is not mentioned. The magnitude of costs associated with implementation and enforcement depends upon the nature of the regulatory measures selected. Enforcement costs for programs requiring either aerial or ship surveillance will be high. Experience with fishery regulations off the Northeast Coast of the United States suggests the need for comprehensive and effective enforcement if regulatory measures are to succeed.

In conclusion, I find myself in agreement with the list of constraints to welfare gains provided by Huppert. I would, however, amend his list to include knowledge deficiencies associated with both biological and economic fishery systems and cost of instituting and enforcing regulatory programs.

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Distributional Implications of the Extended Economic Zone: Some Policy and Research Issues in the Fishery

Daniel W. Bromley

> Welfare economics has a nasty tendency to trail off into philosophy and inaction if pursued far enough (Crutchfield, p. 385).

At a recent conference on the economics of extended fisheries jurisdiction, Bishop and I argued that distributional considerations had been largely ignored by economists as they sought to influence public policy. Among the reactions to that paper, the least surprising was that efficiency analysis is scientific and value free, while distributional matters are value laden, mercantilistic, and concern "love." Another reaction was that to pay undue attention to distributional concerns would freeze us into total incapacity in attempting to "rationalize the fishery." The historical justification for this emphasis on efficiency was that it was difficult enough convincing biologists and policy makers (often one and the same) of the relevance of economics and that therefore it was better to get "half a loaf" rather than nothing. Besides, everyone else is already a "specialist in distribution."

The premise of this paper is that there are important insights to be gained by a more careful specification of the traditional steady-state/yield-effort models and by viewing the economics of extended jurisdiction in a welfare theoretic framework. Length restrictions preclude a comprehensive treatment, yet it is possible to offer some analysis that is suggestive of directions for research. More importantly, I am hopeful that useful policy recommendations might also result.

In the following section I briefly introduce my view of distributional matters as they pertain to the fishery. Then, I present a simple model for assessing the distributional implications of extended jurisdiction in an international setting. Next, I discuss access to the enlarged "domestic" fishery with the primary motive of reminding economists of the elements hidden in that raw number "fishing effort." Finally, I discuss some research and policy implications.

Daniel W. Bromley is a professor, Department of Agricultural Economics, University of Wisconsin, Madison.

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Toward a Working Definition of "Distributional Implications"

Unfortunately, distributional issues get placed in the "love" category, and it is even more serious that distributional concerns are considered to be a mere hinderance to doing "something" in the fishery. That it is controversial and difficult to raise the matter of who gets what in the policy arena cannot be denied, but to dismiss its analytical importance for whatever reason is to indicate a serious lack of appreciation for its role in welfare theory. This brings me to the more serious aspects of the lack of appreciation for distribution. This blind spot exists because the economic models of the fishery are adaptations of firm optimization theory to society as a whole. Let me put it a little differently—distribution has been ignored because economists have been using the wrong conceptual framework.

Traditional fishery models consider fishermen not as independent decision-making units but as mere factors of production aggregated into something called "effort." Firms utilize factors of production according to well-established optimization criteria, adding and subtracting inputs as conditions external to the firm change. Here, distribution is beside the point since there are assumed to be many willing buyers and sellers of said factors. When distribution is discussed, it is in terms of factor payments and income shares.

The yield-effort models hide the fact that individual firms are discussed, which in turn also hire factors of production according to some optimization criteria. Thus, to use the yield-effort model to deal with aggregates of firms is to apply a microeconomic construct to derive policy prescriptions on a macroeconomic scale. We cannot use firm optimization theory to offer prescriptive advice in the large—that is what welfare economics is about.

Once the fishery problem is cast in a welfare theoretic framework, it is ineluctable that distribution is central to any policy recommendation. How else can one say that social state I is better than social state II? These are fishing families that are being retained or restricted out of the fishery, not mere pounds of fertilizer, acre-feet of water, or tons of bauxite. The appropriate maximand for public policy is aggregate social welfare. This is not known until the distributional implications are known (Bromley and Bishop, Graaff, Mishan).

The issue then is how might one begin to develop models of fishery policy that will give explicit recognition to distributional matters? The first obvious step would be to develop a more careful understanding of what is meant by distribution. Is it the Gini coefficient? Is it the percentage of the population that falls in various income (or wealth) quantiles? Or is it something else?

I prefer to consider distributional matters in the context of entitlements and exposure. Imagine a situation in which an upstream landowner has sold the mineral rights to a party wishing to strip mine for coal. There is also a downstream riparian owner of land upon whom excessive sedimentation would be deposited if the strip mining occurs. If government takes the side of the strip miner (entitlement), the downstream riparian will suffer losses (exposure); and if government takes the side of the downstream riparian (entitlement), the would-be miner loses (exposure). Consider another example. I wish to install a solar collector on my roof, but my neighbor to the south happens to have a penchant for tall trees. If government takes my side (entitlement), my neighbor is denied some freedom (exposure), while if the government takes the side of my neighbor I am inconvenienced. Yet another example is found in the famous case of sparking railroad engines; if government protects the railroads the wheat ranchers suffer, and if government protects the wheat ranchers the railroads suffer.

Thus, distribution is here concerned with entitlements to streams of utility and/or wealth over time—in a word, access. But it is also concerned with exposure to the entitlements of others over time—that is, lack of access. The state as an enforcer may help in the determination of entitlements and exposure, but the essence of distributional matters is which party is exposed to the actions of others? Entitlements in an economic system legitimize the imposition of costs on others. My ownership of a piece of land legitimizes the imposition of a cost on anyone who may wish to cross it. My entitlement to dump wastes into a stream legitimizes the imposition of costs on those who may wish the termination of that dumping. Their entitlement to be free of my dumping legitimizes the imposition of costs on me should I want to dump. The structure of entitlements and their enforcement by the state is the mechanism whereby certain costs become legitimized. If I am a fisherman who survives "the cut," my right of access legitimizes the imposition of costs on those who were not so lucky—the cost of being denied access to a way of life and a familiar source of income. This is the distributional component that is concealed in the numeraire "fishing effort."

There is another aspect of distribution—the international dimension. Here, access has the same meaning, and the entitlement legitimizes the imposition of costs on other countries rather than on other fishermen in the same country. In the subsequent section I briefly explore the international dimension of entitlements as they relate to distributional issues.

International Dimensions

(For two excellent treatments of the international fishery, see Anderson and Southey.)

Assume that an area of ocean has historically been fished by two nations (A and B) and that A now declares—unilaterally—part of it to be its sovereign territory; the area and its harvest gained by A is lost by B. In figure 1 we see two interdependent production possibility frontiers (*PLA* and *PLB*) representing the initial (presumably stable) situation. If either A or B alters its level of fish harvest in the commonly fished area, the production locus of the other will shift.

Once A has declared a portion of the area to be its exclusive territory, the two production loci shift to *PLA'* and *PLB'*. Assuming A does not fish in the areas where B also fishes, the interdependence ceases and *PLB'* represents

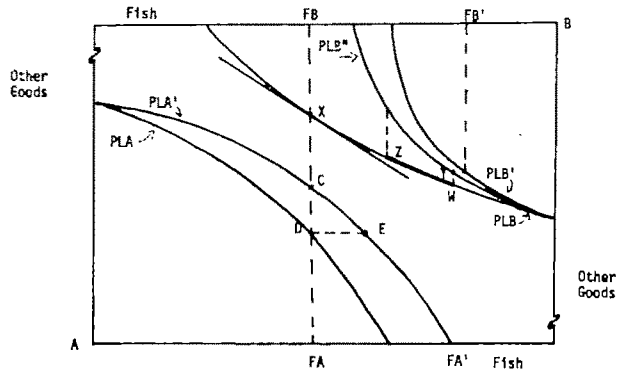


Figure 1

the actual locus of fish production and other goods for B without access to the area now controlled by A. If relative prices for B remain unchanged, its fish harvest would be reduced by the magnitude $FB - FB'$.

With B excluded, country A is now theoretically able to move from point D to point E; this might be thought of as the total allowable catch from the formerly jointly exploited fishery. If the initial open-access situation had represented one of overexploitation, PLA' can be thought of as representing a recovery of the fishery.

Considering first the impact on country B, the exclusion of access to the territory under study would prompt an investment in fishing technology and/or the searching for new grounds to make up for those expropriated by A. Hence, after some time the production locus of B might shift out to PLB''. There, the approximately similar price ratio would result in production of Y. If we assume that B is "settled" at point Y and then country A agrees to allow some harvesting of "foreign catch" in the extended zone, B's effective production locus shifts out to the line segment WZ, with the exact location of Z dependent upon the allowed harvest in the new jurisdiction claimed by A. Since this brings a disequilibrium in B between the marginal rate of product transformation and the ratio of relative prices, it is unclear as to what B will choose to do. If it considers this access as strictly temporary, it may choose not to respond to the offer by A. If it is considered to be long-run access, the line segment WZ becomes part of the production locus and B will respond accordingly.

Turning now to country A, there is the decision as to what constitutes optimum yield and the decision regarding how much will be harvested by A and what can then be offered as "foreign catch." The line segment CE on PLA' represents that locus of output possibilities where it is possible to gain in both outputs. It seems safe to exclude the line segment EFA', since this would entail a reduction in the output of other goods and services. Between C and E there are issues of the current trade position in fish and in other goods, as well as the degree of fishing capacity to harvest the newly claimed endowment. Should it turn out that A is unable to take full advantage of the new entitlement, and country B is not allowed to harvest any fish from the extended jurisdiction, it might seem that country A has been made only slightly better off, while B has been made markedly worse off, though more analysis would be necessary to be certain about this.

To simplify the analysis current and potential consumption, import and export magnitudes have been ignored. It is also possible to derive utility possibility frontiers for A and B from the various production loci. My interest in this type of analysis lies in its ability to depict intercountry relationships in a fishery when there is a unilateral change in entitlements. The recent confrontation between England and Iceland over fishing access is an interesting example of two countries with drastically different production possibility frontiers between fish and other goods. The tenacity with which Iceland resisted British fishing activity tells us something of the marginal rate of transformation of fish for other goods in Iceland.

Distribution in the Domestic Setting

"Since the allocation of permits is, in essence, a matter concerning the distribution of wealth, it will inevitably become controversial and difficult. 'Who *should* get licenses' is not an

issue on which economists have much to say. It is rather, a matter for negotiation among fishermen and administrators" (Christy, p. 150). This quote asserts that economists do not have much to say on who gets access to the fishery, yet we sometimes hear contempt for administrative or judicial decisions that reserve part of the fish harvest to the native Americans.

Another economist who has worked extensively in the fishery says:

> Extended jurisdiction in itself solves very little. Used improperly, it exclusively reserves to the U.S. the right to squander its valuable capital and labor through the imposition of quotas to insure that fish are "saved." The way to repair the market failure is through the transformation of common property resources into private property resources. I see no one worried about the conservation of chickens, pigs, cows, or turkeys (Bell, p. 24).

This curious statement highlights the distributional quandary among fisheries economists. On the one hand we are told that the economists have nothing to say about who gets access, then we often hear that returning part of the catch to the American Indians is a mistake. Finally, we are told that the fish need to be converted into private property. But whose property? Obviously not the Indians' if we listen to some; the highest bidder's if we listen to others. But we must be careful how we define the highest bid.

Assume that the domestic portion of allowable catch has been determined and that there are three (homogeneous) groups of fishermen seeking permission to fish. The usual answer is to sell licenses or certificates to fishermen, thus extracting some of the rent for the state and insuring that those who value fishing the most would get in. In table 1 I have depicted three groups of fishermen: "commercial" fishermen (CF), American Indians (AI), and "marginal" fishermen (MF). Assume that both CF and AI are serious "full-time" fishermen, although there are important differences between their two operations. CF consist of heavily capitalized fishermen with the latest technology who catch great quantities of fish but who incur considerable cost; assume a net present value of access to the fishery of 105. For AI, fishing is much more labor intensive, and while catch per unit of effort is lower than for CF, so are costs. Thus, I assume a net present value for access to the fishery of 100. As for MF, this group has neither the modern technology of CF nor the skill of AI; this group is rather nonchalant about fishing and is capable of a variety of other work. Assume that the net present value of access for this group is 60.

Table 1. Net Present Value for Three Groups of Fishermen

	CF	AI	MF
NPV_F	105	100	60
NPV_A	95	30	45
$NPV_F - NPV_A$	10	70	15

Note: Figures assume each group is alone in the fishery.

Consider the alternative occupations for the individuals in these three groups. For CF, boats could be sold, and these individuals might fare rather well in nonfishing occupations. For AI, we cannot assume that things would go so well; this group is not well suited to occupations other than the traditional one of fishing. Finally, as indicated, those in MF are moderately adept at finding alternative employment. The net present value of these groups in their best alternative is depicted in the second row of table 1. The final row in table 1 shows the difference in net present value for each group between fishing and their assumed best alternative—it is the opportunity cost to them, and to the nation, of being denied access to the fishery.

Assuming all of the fishermen in only one group are to gain access, which set of figures is relevant? The "commercial" group has the highest net present value in the fishery, but this group also has the best on-shore income potential. The "marginal" fishermen do not fare so well in terms of income generated in the fishery, though they do not experience a serious decline if denied access. But the Indians would be the one to suffer the greatest fall in income from being excluded from the fishery.

The difference between NPV_F and NPV_A might be considered an index of the willingness to pay of each group to have access. But, the great difference between this figure for CF and AI must be interpreted with care. If the Indians' "willingness to pay" (70) is an imputed value rather than the result of market transactions (as we might assume is the case for CF), then their ability to enter a bidding contest with CF (or even MF) may be seriously constrained. If this group does not have access to capital markets, it may be even more seriously disadvantaged by a competitive bid-

ding scheme for licenses. If we think of the figures in the table as the real net income of each group in the two possible occupations, and if only one group can have access, then present-valued income is enhanced if AI have access to the fishery and the other two groups do not. Here, aggregate net present-valued income is 235 compared with 180 for CF in the fishery and 185 for MF having access. Indeed, assuming that the interaction effects are zero and that it is possible for two groups to have access to the fishery, aggregate net present-valued income is highest in this example if CF are denied access ($NPV = 95$) while AI and MF are allowed in (100 + 60). Thus, the appropriate way to allocate limited access to the fishery is by a careful accounting of the alternative income earning potential of all petitioners and by a realistic assessment of their ability to bid for limited access.

Policy and Research Implications

Without condoning the territorial imperialism of the extended economic zone, I share with other economists the sense of optimism concerning the opportunity for improved fishery management. Yet I am worried that "Crutchfield's Complaint" (opening quote) may continue to find sympathy among economists. Fishery economics and policy is concerned with the study of alternative institutions pertaining to who may fish, what technology will be employed, when and how fishing may occur, and what will happen to the harvest. These are matters that cannot be dealt with in an economic framework other than welfare economics; intellectual honesty will allow no other approach. I am sorry if welfare economics is not as "well behaved" as conventional price theory or firm-optimization models. But there must be a more compelling reason to avoid appropriate economic models than the mere fact of intractability. It is indeed inconvenient for those who feel constrained to have quick advice for policy makers that welfare economics has a "nasty tendency to trail off into philosophy and inaction if pursued far enough." But is the correct response to thus ignore welfare theory and its distributional imperative?

The big gainers and losers of any management scheme are the fishermen themselves. One need only look at the livestock industry in the West, where access to public grazing lands is so crucial, to appreciate the devastating long-run economic loss of those who were not so fortunate as to gain access; efficiency issues pale in comparison with the distributional ones. Entitlements to a resource are the key to policy-relevant analysis. When a certain subset of those who currently have access sit on planning bodies designing management schemes—including gear type, vessel size, total annual catch—it does not take much intuition to begin to understand "whose ox is being gored."[1] When a large contingent of politically aware sport fisherman take on a few commercial fishermen, it is not difficult to imagine who will win. Surely economics has something to offer in this important policy issue.

I have tried to offer several suggestions for introducing distributional considerations into the analysis of both international and domestic fisheries policy. I have no illusions that it will be simple, but I reject the notion that we should press the economic management of fisheries "as far as possible on allocative or efficiency criteria before modification if absolutely necessary, by equitable or distributional criteria" (Scott, p. 410).

On the domestic front, a distributionally related management program would begin by paying careful attention to the real mobility (both monetarily and nonmonetarily) of all who would seek access. Economists have talked for too long of managing fisheries for the greatest economic benefit to the resource rather than for the economic benefit of the nation; this latter concept includes those involved in the fishery as well as those precluded from involvement. I am dismayed at the cavalier way in which some talk of denying access to the fishery. My friend, Jim Crutchfield, approvingly discusses the situation in the state of Washington by saying: "the drive for a limited entry program that severely restricts effort is coming from an industry group rather than the preachings of academic people" (p. 384). Yet where do we suppose industry groups get the imprimatur for making others worse off so that they (those in the fishery, organized, and probably more "successful") can be made better off? Could it be from "academic preachings" that refer to this redistributional approach only in terms of achieving efficiency in resource use?

[1] In Wisconsin's Lake Superior, fishery access is constrained by a $10,000 investment, $5,000 of annual (historical) catch, and at least 75 days of fishing per year.

Moreover, the move toward limited entry is often dismissed as being of minor harm—and far outweighed by the good resource allocation implications. "While it (limiting entry) may confer unearned windfalls initially, once those rights become established as transferable property their price thereafter will pretty well limit the rate of return to new entrants to a competitive level, and allocative benefits will be realized. There will be a desirable tendency for those permits to gravitate to those who can use them *efficiently and professionally*. The negative impact will occur only in a once and for all fashion" (Crutchfield, p. 385, emphasis added).

I suspect that the concern with giving part of the harvest to Indians is because we suspect that they are not "efficient and professional" and that they are probably disinclined to treat the rights of access as "transferable property" that would someday gravitate to those who are professional and efficient.

Yet distributional analysis is concerned precisely with who gets what. We cannot be so casual about the fact that the negative impacts are merely of the "once and for all variety"—access denied is precisely that, and while our value judgments about who should get access are immaterial, we do have an analytical interest in the process whereby some obtain access and some do not.

Economists should be able to build models of the differential level and incidence of transaction costs that are relevant to the sort of subtle (and often nonsubtle) bargaining about who gets what. We should be able to build models of international comparative advantage that would be helpful in understanding the opportunity cost to various nations of denying them access to our extended economic zone. We should be able to disaggregate "fishing effort" into its component parts so that we do not continually beguile ourselves into thinking that it is some homogeneous and standard input. We should be able to build fishery models that somehow recognize that there are individuals of a wide variety of skills and capital equipment in the fishery and with a wide disparity of economic opportunity outside of the fishery. We must remember that the optimal way to manage the fishery is as an integrated industry with all others. It is nonsense to manage fisheries for the maximum economic benefit to the resource. If we make the political decision not to exterminate any fish stocks, economic theory tells us to manage that small segment of our extractive resource base for the greatest possible benefit of all of us. As unhandy as it may turn out to be, this is what welfare economics is about.

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Distributional Implications of the Extended Economic Zone: Some Policy and Research Issues in the Fishery: Discussion

Richard S. Johnston and Frederick J. Smith

We heartily applaud Bromley's paper. As expected, it is provocative. We agree with his premise that "there are important insights to be gained by a more careful specification of the traditional steady-state/yield-effort models and by viewing the economics of extended jurisdiction in a welfare theoretic framework." However, we are concerned with two particular aspects of the paper.

Bromley seems to go beyond the identification of distributional consequences of fishery policy and suggests certain fishery policies because of their distributional consequences. Economists generally employ theoretical constructs in order to predict the consequences (distributional or otherwise) of alternative policies. Theoretical constructs do not prescribe policy "for the greatest possible benefit of all of us." Economists must therefore doff their economists' hats when they enter the policy-making arena. Bromley does not tell us when he is wearing his economist's hat and when he is wearing his manager's hat (nor do Crutchfield or Bell, as quoted in Bromley's paper). We would prefer a clearer distinction between Bromley's use of welfare theory to provide policy prescriptions (normative) and Bromley's use of welfare theory in predicting consequences of policy decisions (positive).

Our second concern relates to the role of distribution in welfare theory. Bromley argues that efficiency (or maximum net economic rent) is only one socially relevant variable. We agree. He then introduces distributional considerations. Does this imply that distribution is another socially relevant variable, or is distribution another dimension of efficiency?

If distribution is another socially relevant variable, are there not many more that deserve consideration? The Fishery Conservation and Management Act of 1976 contains an extensive list of socially relevant variables. Our own experience suggests that fishery participants would rank efficiency fairly low on an extensive list of socially relevant variables.

If distribution is another dimension of efficiency (as implied in Bromley's discussion of "access"), what of the distributional dimensions of the other socially relevant variables? We suspect that the current controversy over allocation of fish (or fishing rights) is more closely related to who gets fish, flexibility, etc., than to who gets what share of the maximum net economic rent. In substituting the net economic rent criterion for the maximum sustainable yield criterion, economists have exposed themselves to the same criticisms leveled at proponents of the maximum sustainable yield criterion. Our model is still single valued and incomplete.

Fortunately, the new management regime created by the Fishery Management and Conservation Act of 1976 provides for public hearings where potential gainers and losers cannot only identify socially relevant variables but can express priorities for distribution.

Bromley emphasizes that fishing families are "not mere pounds of fertilizer, acre-feet of water, or tons of bauxite." We find it unfortunate that he dismisses, by implication, the rewards accruing to owners of fertilizer, water, and bauxite, who may also have families.

The international model presented by Bromley appears to have a variety of interesting applications. For example, it might be used to predict the reaction of Japan (i.e., country B) to the current management policies under the U.S. (country A) Fishery Conservation and Management Act of 1976. In contrast to Brom-

Richard S. Johnston and Frederick J. Smith are with the Department of Agricultural and Resource Economics, Oregon State University.

ley's example, fish (does "fish" in Bromley's model refer to fish stocks or fish production?) are not unilaterally expropriated by country A but are initially allocated between countries A and B roughly in accordance with the status quo. Also in contrast to Bromley's example, the new management regime does not shift production possibility curves. However, we would expect the production possibility curve of country A to shift outward in the direction of F as the perceived risk (and therefore cost) is reduced by the very existence of the Fishery Conservation and Management Act of 1976.

We face a dilemma in predicting the eventual allocation of fish between countries A and B. Bromley implies that the beginning allocation of fish, FB to country B and FA to country A, is less than optimum for country A and optimum for country B. The optimum for country B appears as a tangency point equating marginal costs to price ratios. Unilateral fishery policy by country A presumably allows it to achieve a similar tangency (or internal equilibrium). But doesn't that tangency represent maximum efficiency, the very single-dimension criterion that Bromley decries?

The eventual allocation of fish between countries A and B then depends upon the new country A production possibility curve location and the management criterion used in determining tangency. With the quota approach to allocation, country B's production possibility curve is discontinuous at the quota level—a situation requiring extreme country B measures to accomplish some internal equilibrium (such as joint ventures with country A fishing firms, aggressive buying of country A inventories, influence peddling, etc.).

Bromley's example in table 1 is a little confusing. Is $NPV_F - NPV_A$ a row vector of "rents"? If so, will not maximizing this rent to the resource come about through the bidding process by which the highest bid comes from group AI and the lowest from group CF? It seems that rents can be determined only after consideration of alternative income sources. The meaning of net present value is not clear. Does "net" mean "receipts less all costs?" If so, NPV_A is already accounted for in the NPV_F row and $NPV_F - NPB_A$ has no relevance.

In conclusion, we would have preferred a little more caution in the prescriptive use of welfare theory and a clearer interpretation of the role of distribution in welfare theory. We are still very much in sympathy with Bromley's desire to view "the economics of extended jurisdiction in a welfare theoretic framework." However, our illustrations and examples must be more cogent and consistent. We must not stop at distributional considerations; we must also give some attention to other socially relevant variables in fisheries policy research.

Distributional Implications of Extended Fisheries Jurisdiction: Some Research and Policy Issues: Discussion

Darrell L. Hueth and Virgil J. Norton

Bromley's paper draws attention to the importance of distributional considerations in fishery management decisions (as in Bromley and Bishop), and he suggests these implications be identified before such decisions are made. Bromley also attempts to demonstrate how distributional considerations can be used to evaluate policy questions arising from extended fisheries jurisdiction in international and domestic settings. While these points are important, he has not clarified these concepts sufficiently for them to be useful in identifying policy and research issues.

The general equilibrium analysis of international fisheries is confusing. It is difficult to understand the interdependent production possibility curves presented in his figure 1. The production possibility frontiers of countries A and B without extended jurisdiction are given by *PLA* and *PLB*, respectively. His presentation seems to indicate that complete specialization in fisheries by both countries would produce more fish than it is possible to produce (i.e., the width of the box). If it is intended that movements along a frontier (*PLA*, for instance) shift B's frontier, this would, in turn, shift A's frontier and, thus, *PLA* becomes meaningless except for point *D;* that is, if there is interdependency as he indicates, *PLA* and *PLB* cannot simultaneously hold.

This figure is basic to his entire international presentation, and therefore the appropriateness of conclusions drawn from the international section is questionable. We would, however, be interested to learn more about the metric and the type of analysis he implicitly introduces in his otherwise ordinal analysis by suggesting that "it might seem that country A has been made only *slightly* better off, while B has been made *markedly* worse off, though more analysis would be necessary to be *certain* about this" (emphasis added).

Bromley's analysis of distribution in the domestic setting begins with three groups of fishermen seeking permission to fish. He implicitly assumes there would be a limitation on total effort within each group (the value of the license or right to fish to any group without such limitations would be zero) and asks the question: to which of these three groups—commercial fishermen (CF), marginal fishermen (MF), or American Indian (AI)—should the licenses be granted?

He concludes that, even though the "net present value" of fishing (NPV_F) for AI is lower than for CF, calculation of the "relevant figure" implies allocation to this group. To arrive at this conclusion, he assumes that, while the NPV_F is lower for AI than for CF, the net present value of onshore employment NPV_A is far less for AI than CF. Hence, the difference in net present values $NPV_F - NPV_A$ is greater for AI than CF.

We have two concerns about Bromley's analysis. First, he has made important implicit distributional decisions regarding allocation within each group or, as is mentioned above, there would be no economic rent or willingness to pay for access to the resource. We are surprised that he allows this to remain as an implicit assumption since he later indicates, "I am dismayed at the cavalier way in which some [economists] talk of denying access to the fishery." Obviously, the approach in this section involves denying access to the fishery to someone in each group. Distributional questions within as well as among groups should receive attention.

Second, we question Bromley's calculation of willingness to pay for access to the fishery. He assumes a net present value of access of

Darrell L. Hueth is an associate professor and Virgil J. Norton is a professor of resource economics, University of Rhode Island.

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105 for one group (CF) and a net present value of their best alternative to be 95 (his table 1). Why, if CF can earn a present value of 95 onshore and 105 fishing, would they be willing to pay anymore than 10 for the right to fish? Only if CF were unaware of these onshore employment opportunities (which would then change their private opportunity cost) or if CF obtain utility from fishing (not mentioned by Bromley) would this seem to be the case. Traditional analysis suggests that opportunity values would be included as a cost in calculation of NPV_F. Therefore, what Bromley calculates as $NPV_F - NPV_A$ would, in fact, represent willingness to pay for access. Following this, the implication of Bromley's example is that AI would have the highest willingness to pay. Thus, Bromley seems to be suggesting that access be allocated to the highest bidder, a procedure he questioned earlier.

Moreover, since social rents to a resource are appropriately calculated by summing the net present value of total revenues minus total costs where total costs are the social opportunity costs, the allocation to AI also maximizes rents (or benefits) to the resources, which, Bromley argues, is "nonsense." In the domestic analysis, it appears to us that Bromley is simply arguing: allocate on the basis of economic efficiency, but calculate the benefits and costs properly.

On the subject of properly calculating benefits and costs, while Bromley's introductory comments regarding entitlement and exposure are interesting, he did not relate this discussion to his later analysis of distribution in the domestic setting. Also, in various examples given, he fails to consider the role of compensation in the alternative proposed solutions. Therefore, the section "Toward a Working Definition of 'Distributional Implication' " is not helpful in interpreting the remainder of his paper. Certainly, this section and the international and domestic analyses do not provide the conceptual approach we hoped would be present when he indicated that in past analyses by other economists "distribution has been ignored because economists have been using the wrong conceptual framework."

On a more general point, Bromley correctly points out, "The appropriate maximand for public policy is aggregate social welfare." We are concerned, however, about the implications of his next statement: "This is not known until the distributional implications are known." The function that maximizes aggregate social welfare is not and cannot be known. Hence, even with the distributional implications we can never say that any social state I is actually better than social state II. At best, from the new welfare economics we can define an increase in potential real income and then only under certain conditions (see Samuelson, p. 11).

Does this mean that economists must abandon the fisheries policy field to the biologists? Certainly not! As Bergson has stated, "Before committing himself, the public official will surely wish to know whether, according to any usual calculation, the measure in question would be economically advantageous or disadvantageous . . ." (p. 41).

To provide this necessarily incomplete information to decision makers, however, one must shift from the purely ordinal general equilibrium framework to an approach that provides a basis for cardinal measures, namely, the economic surplus framework. This approach has the additional conceptual advantage of allowing us to identify income distributional consequences of alternative policy decisions since it is explicitly developed from individual (human) behavior.

Estimates of yield-effort models could provide important input into welfare studies using this approach. Thus, in contrast to Bromley's suggestion that we break out of the traditional steady-state/yield-effort models, such models represent one input into an appropriate economic surplus framework that may allow for distributional comparisons.

There is enough theoretical and empirical evidence to indicate that public action in management of fisheries, like petroleum in the ground and radio frequencies, represents a potential social gain. We assume Bromley would accept this position. Thus, a basic research question is to identify the efficiency effects of alternative management techniques. Certainly, when possible, the distributional consequences of these alternatives should also be presented; but even when they cannot, estimates of potential gains will be useful information in the decision process.

If economists want to have an input into decisions, we may wish to take the advice of Scott (p. 414); that is, we should attempt to predict the most likely actions of the Regional Management Councils and initiate research in the areas that will provide an input into these actions. This approach may suggest that research is needed in the following areas: (*a*)

industry structure, conduct, and performance in order to determine whether potential gains from extended jurisdiction will be passed on to consumers or captured as producer surplus; (*b*) comparative cost and trade studies to determine the implication of eliminating foreign effort from the U.S. economic zone; (*c*) economic implications of alternative methods of controlling incidental catch in multispecies fisheries; and (*d*) economic issues involved in allocation of fish to commercial and sport fishing activities (Brown and Schuler have addressed some distributional implications of this issue).

These issues are currently being considered by the councils. Each of these issues carries important efficiency and distributional implications. Economic tools do not provide the basis for choosing among distributional alternatives. However, economists can identify and measure the magnitude of the efficiency and distributional effects. Recent advances in economic surplus methodology have substantially enhanced the economist's capability to determine and interpret these magnitudes (see, for instance, Just and Hueth, Schmalensee, and Willig). Applications of these measures to the fishery will represent essential information for the decision makers who must choose among the alternatives.

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Measuring the Effects of Commodity Stabilization Programs on Supply Response and Social Welfare
(Richard G. Heifner, Economic Research Service, USDA, Chairperson)

What Do We Know About Agricultural Producers' Behavior under Price and Yield Instability?

Clifford Hildreth

Unstable prices and yields imply uncertain prices and yields. One could imagine a situation where controlled prices were announced well in advance but fluctuated according to perceived circumstances at the times of the announcements. Some agricultural programs have approximated the latter, but the main interest here is in supply response with price unknown at the time production and tentative marketing decisions are made.

In considering producer behavior in the United States, it is worth noting that 70% of cash sales are furnished by the 450,000 farms (16%) having sales of $40,000 or more. On the average, each operator in this group controls nearly a million dollars worth of farm assets. Thus, supply response is principally determined by a group of highly competitive, respectably sized businesses. Direct observation supports the theoretical conjecture that survival or growth in such businesses requires intelligent, industrious, and informed managers. So the mental image I have of the party whose decisions we want to understand is that of an alert, sophisticated person continually mingling physical and supervisory tasks with a wide assortment of calculations and gathering and sifting a variety of relevant information.

Difficulties in Achieving Firm Knowledge

Our knowledge of the decision-making processes of these farmers comes primarily from three sources: (*a*) experiences of people who work closely with farmers—feed dealers, implement dealers, extension workers, buyers, etc., including farmers themselves; (*b*) theoretical models of behavior; and (*c*) econometric studies.

Interdependencies between the sources are clear. Advances in each are made by drawing on the other two. For example, a good econometric model builder tries to represent plausibly important judgments of experienced people and to reproduce aspects of the more promising general theoretical models. The results then provide some evidence as to the validity of the judgments and the relevance of the theories. Many extension workers and agribusiness trainees study theory and consult econometric studies to interpret their experiences more coherently.

To make a specific appraisal of how much we know about producer behavior under uncertainty would indeed be a formidable task. It would involve testing the forecasts of experienced people and the best models we could construct as well as forecasts by people of good judgment with access to all sources. An important question would be the relevance of past experience and analysis to a situation changed by such factors as changing impacts of government programs, increased contracting, changing international trade policies and patterns, etc.

I have not the resources to make such an appraisal and am inclined to doubt that a large undertaking would be the best use of research resources now. I think that the forecasting record would be sufficiently mixed and tests of econometric models would reveal sufficient possibilities of sampling and specification

Clifford Hildreth is a professor of economics, University of Minnesota.

error that the pressing need we feel to improve our understanding would be reinforced. I, therefore, turn my attention to some possibilities for improvement. The possibilities are numerous, and some very perceptive people disagree on what is most promising. Let me label what follows as one person's opinions without implying that any of the opinions are new.

Further development and empirical exploration of expected utility models of producer behavior seem promising avenues at this stage. Studies like those of Officer and Halter; Lin, Dean and Moore; and Just tend to confirm our notions that farmers are predominately risk averters. One expects this to lead to somewhat lower output than if average prices and yields could be known and stable. However, this tendency must be partially offset by loss shifting provisions of tax laws and investment credits. To further test our current notions and to obtain more precise relations, extensions and modifications of such studies should be undertaken. Before making some specific suggestions, I note two relevant developments.

Related Developments

Financial gain is not the only incentive shaping human behavior. Social status, religious values, domestic tranquility, leisure, and aesthetic enjoyments might immediately be cited in the case of our producers. This has led to analysis of multiattribute utility models in which the expectation of a function of several variables is presumed to be maximized. Keeney and Raiffa have prepared a stimulating exposition of such models and experiences with them. Certainly, such models for agricultural producers should be formulated, analyzed, and tested.

However, my conjecture is that when this is done the narrower utility of monetary gain model will be a useful approximation in many instances related to year-to-year supply. My impressions from introspection and from recent interviews with a panel of Minnesota farmers (work partially supported by the Economic Research Service and not yet reported) is that nonfinancial considerations typically enter very importantly into the decision to farm and the decision of the kind of farm to organize. But, once these decisions are made, I suspect that financial considerations dominate most of the year-to-year production and marketing decisions so long as the basic organization of the farm is not reconsidered.

Of course, personal tastes will be indulged when the financial considerations are not large. A farmer who has fed Holsteins (there are dairy herd liquidations in his area) for several years remarked last spring, "I'll be glad when I can go back to beef steers; they're nicer to watch." However, these motivations are not apt to affect supply relations greatly. For me, the upshot is that it seems desirable to start developing multiattribute models for some aspects of producer behavior, but I would not like to see this interrupt further development of financial gain models in appropriate settings.

Another relevant line of thought worth noting is associated with topics like satisficing, adaptive economics, and bounded rationality (see the book edited by Day and Groves). Very loosely, a decision maker typically has a variety of goals. He formulates a more-or-less precise strategy that seems to offer the chance of substantially achieving these goals and proceeds.

As long as achievement is substantial, the strategy is likely to be retained. When sufficient disappointment accumulates, a search for a new strategy is undertaken. A complete ordering of outcomes is not always assumed. Traditional economic theory is too rigid and narrow in postulating a precise individual equilibrium that maximizes utility or expected utility.

Even in the above garbled version, the approach has considerable merit. I still see, however, considerable promise in the further development of expected utility theory in contexts in which the decision maker may be expected to closely comply with the axioms that permit an expected utility representation (see Fishburn for a reformulation and brief historical sketch).

Consider the following possibility. Global lifetime decision making (Savage's grand world) is perceived as proceeding according to some metamodel that might or might not be Bayesian. Within the metamodel the decision maker sometimes formulates (or acts as through he formulates) expected utility models of specific decision problems (Savage's small worlds).

One function of the metamodel is to indicate when smaller models are to be reconsidered. Reconsideration might include (*a*) states of

nature regarded as possible and the prior distribution of states; (*b*) the flow of information used to successively form new posterior distributions and the statistical models used to interpret new information; (*c*) the space of possible actions; (*d*) the relation specifying a consequence for each state-action combination; and (*e*) the decision maker's perception of his utility function.

A possible advantage of the expected utility framework for small problems is that the kinds of difficulties encountered may provide hints of promising reexaminations. Two cases are obvious. If states of nature that were not contemplated occur, the state space has to be broadened. If realized outcomes do not yield the anticipated satisfaction, the utility function is not well articulated.

Assuming neither of the above, realized utility may still not agree very well with expected utility. Once an action has been chosen, the decision maker has a subjective distribution of outcomes and a subjective distribution of possible realized utilities. For convenience, call these the final distributions. If realized utility is consistently low—say, it is consistently below the mean of the final distribution—this suggests difficulty in the expectation formation process. Better information may be needed; the statistical model through which information is interpreted should be tested; the decision maker may be using a very precise prior that does not respond to new information.

On the other hand, it could happen that realized and expected utility tend to agree reasonably well over time, but both are consistently low. Optimal plans just do not provide much chance for happy outcomes. In this case, the available actions would seem to be a logical place to start reconsidering. If modest reconsideration does not yield something helpful, actions like hiring a consultant or going out of business might be contemplated.

The above might be described as common sense in special jargon. If Bayesian models lend themselves to using common sense, this seems to the good. It is to be hoped that in specific contexts the kind of trouble-shooting described might lead to more specific remedies than unaided common sense. So my current reaction to the satisficing, bounded rationality development is that it appears interesting and worthwhile but not inconsistent with the continued useful development of familiar expected utility models in suitable contexts, including aspects of supply responses.

Improvements in Expected Utility of Wealth Models

Assuming there is a wide range of agricultural supply problems to which expected utility of gain or wealth models can be usefully applied, I have several suggestions for the continued development of such models.

It has been recognized from the outset that the choice that maximizes expected utility will lie on the efficient mean-variance frontier only in special cases. Quite a few investigators have, however, conjectured that analysis in terms of mean and variance might frequently yield approximately optimal decisions and have continued to use this approach. It seems to me that we need to broaden our approach, to test mean-variance analysis against alternatives, and to use it only when there is good reason to believe that it does furnish a suitable approximation.

Use of mean-variance has frequently been accompanied by polynomial utility functions. Polynomials have the distinct disadvantage that behavior of the function for large values of its argument is determined by the sign of the coefficient of the highest order term. Both alternatives are implausible. If the coefficient of the highest order term is positive, the polynomial is, and remains, convex for sufficiently large wealth. If the coefficient of the highest order term is negative, the function becomes downward sloping—less wealth is preferred.

One can claim that a particular polynomial is a good approximation to utility in the relevant range. The difficulty is that the relevant range depends on the particular alternative choices contemplated. Changing these involves changing the relevant range and having to reverify and possibly change the utility function.

Keeney and Raiffa report several increasing, concave functions that permit decreasing absolute risk aversion. Among those reported are

$$u(x) = \sum_{1}^{N} a_i e^{-b_i x},$$

$$u(x) = a + b \log(x + c),$$

$$u(x) = a + b \log(x + c - d|x|),$$

$$u(x) = a + b \log(x + c - d[(x^2 + f^2)^{\frac{1}{2}} - f]),$$

and

$$u(x) = a + bx^c.$$

I have occasionally used

$$u(x) = ax - be^{-cx},$$

which is simple and also has the properties usually sought.

We should, of course, continue to check the possibility that utility functions have convex regions. My current conjecture is that risk aversion probably dominates business decisions. An argument tending to support this conjecture is given in the appendix.

Particular decision problems are never encountered in a vacuum. While a decision maker deals with uncertainties associated with some aspects of his life, other uncertainties exist and are typically relevant to his current decisions. It seems reasonable that uncertainties in livestock enterprises should be relevant to a farmer's crop decisions. His holdings of securities are relevant to all his farm planning. I have called these background uncertainties the initial prospect (Hildreth 1974b, Hildreth and Tesfatsion). It turns out that the initial prospect does not have to be explicitly taken into account if it is known to be statistically independent of the ventures currently considered. Whether or not this is the case needs to be carefully considered in each application.

There are, of course, hosts of other problems that require early attention. Multiperiod models, effects of the tax structure, and the process of expectation formation are immediate instances. Finding things that need doing is not a current problem. As models of producer decisions become more complete and more firmly established, they will have implications for econometric models of market behavior and for models of public decisions. For example, a frequent assumption in econometric models is that expected price is a linear function of past prices with coefficients following some predisposed pattern.

In early July 1977, I found several beef feeders uniformly optimistic about next summer's prices. More adequate feed to halt herd liquidation was the principal reason. Expected inprovement in the general economy was next. I cannot help wondering how well the historical price sequence captures such considerations. With regard to public decision, a large part of the Keeney and Raiffa volume cited earlier is concerned with extending expected utility reasoning to this realm.

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Appendix

Suppose Mr. A has the Friedman-Savage "typical" utility function shown in figure 1 while Mr. B has the concave function of figure 2. The latter is similar except for the linear segment over $[x_1, x_2]$.

Suppose A and B can place fair bets with arbitrary probabilities and appropriate stakes of size $x_2 - x_1$ or smaller. If A finds himself with wealth x_3, he can quickly achieve expected utility y_3 by placing a bet that will pay $x_2 - x_3$ if an event with probability $\frac{x_3 - x_1}{x_2 - x_1}$ occurs and will cost $x_3 - x_1$ if not. Thus, we expect to observe A at x_3 only momentarily.

Suppose A and B are both at x_4, and each is considering a venture that will gain $x_5 - x_4$ or lose $x_4 - x_3$. If p is the probability of success, then B's expected utility if he pursues the venture is $py_5 + (1 - p)y_3$, and he will pursue if and only if $p > \frac{y_4 - y_3}{y_5 - y_3}$.

If A reckons in terms of his utility of wealth function, his expected utility on taking the venture is $py_5 + (1 - p)w_3$, and he will pursue if and only if $p > \frac{y_4 - w_3}{y_5 - w_3} > \frac{y_4 - y_3}{y_5 - y_3}$. However, if A thinks one step ahead and recognizes that he will quickly take the previously noted fair bet if he does land at x_3, his contemplated expected utility under the venture is $py_5 + (1 - p)\frac{x_3 - x_1}{x_2 - x_1}y_2 + (1 - p)\frac{x_2 - x_3}{x_2 - x_1}y_1 = py_5 + (1 - p)y_3$, which is the same as the contemplated utility of B. Thus, starting from x_4, and assuming that A's potential bets depend on an event independent of the venture being considered, A and B accept exactly the same ventures. Their behavior is indistinguishable except that A may sometimes be detected making supplementary fair bets after observing the outcomes

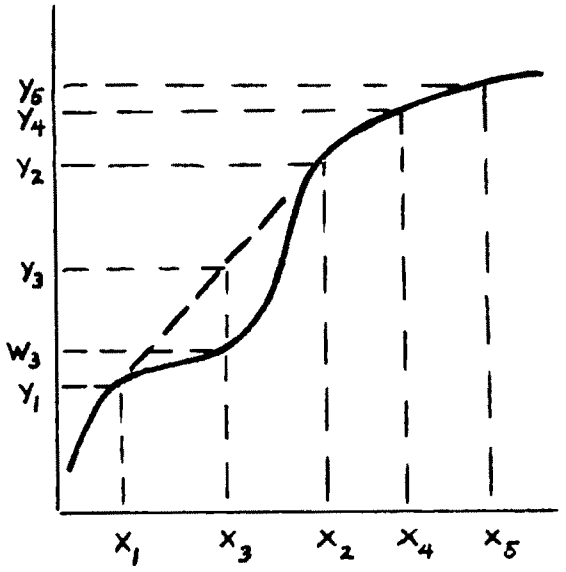


Figure 1

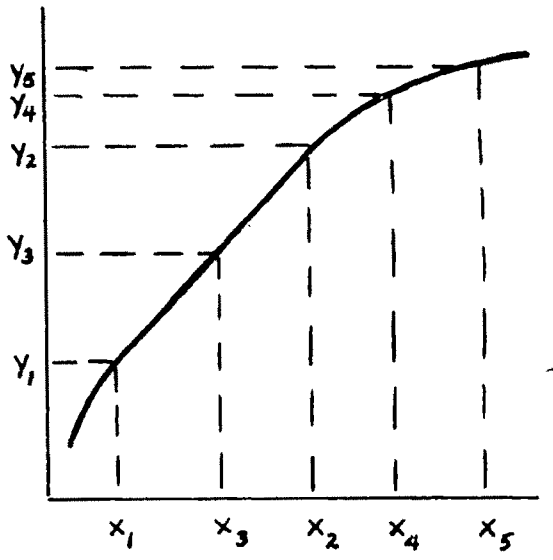


Figure 2

of his ventures. It is easily verified that this is true regardless of starting point.

In our economy there may not be fair bets of every desired size and odds. However, a very wide assortment of nearly fair prospects is surely available from Las Vegas, commodity futures, commodity options, stock options, foreign currency, and many less exotic business opportunities. If purchasing a commodity future is an unfair prospect, selling it can be unfair by at most transactions costs that are small.

Sophisticated producers who mainly account for fluctuations in supplies of farm commodities must typically be aware of some of these opportunities. In some cases the potential bets are not independent of contemplated ventures, as, for example, a wheat farmer whose venture is expansion and whose contemplated bets are wheat futures. Dependence can be better or worse than independence and needs careful exploration (this is stressed in Hildreth 1974a, Hildreth and Tesfatsion, and Just). If he desires, the wheat farmer can get an independent or nearly independent bet by using Congo currency. Also, A could, for practical purposes, convert a purchase of a commodity future into an $(x_2 - x_3)$ versus $(x_3 - x_1)$ bet by arranging to close his position as soon as he had either made $x_2 - x_3$ or lost $x_3 - x_1$.

Modified models that more completely reflect circumstances of particular kinds of entrepreneurial situations should be examined, but I believe these considerations establish a presumption that convexities lying between concave segments in a pure utility of wealth function may be taken to be substantially "filled in" when business ventures are contemplated.

Measuring Aggregate Supply Response under Instability

William Lin

In spite of the strong interests that agricultural economists have had in measuring aggregate supply response in the past, there are only a few studies that explicitly introduce the risk element into the models (e.g., Behrman, Just, Traill). Behrman quantifies both yield and price variabilities by using three-year moving average standard deviations about a simple moving average of yield and price. Just formulates a risk response model by assuming that decision makers would form their risk expectations by geometrically weighting past observations of risk similar to the way in which price and yield expectations are formed. The risk variable was taken to be the square of the difference between the actual explanatory variable (such as gross return) and the expected values. Each lag variable was then divided into observable and unobservable parts similar to the approach suggested by Klein. Assuming the disturbance term follows a normal distribution, an iterative procedure was undertaken to derive the maximum likelihood estimates of the regression coefficients, given values of the lag parameters and the internally generated risk observations. Results obtained from Just's multivariate adaptive expectations model often indicated risk to be significant in acreage response.

Traill uses a polynomial lag to measure onion acreage response at the national level. He utilizes an iterative procedure to first estimate the distributed lag effects of the past price variables, then formulates the risk observations by quantifying the absolute deviations of the actual and expected prices. Expected risk is then specified as a distributed lag function of past observations of risk. He found that a simple two-year moving average standard deviation of past actual prices performs at least equally as well as the iterative procedure.

The remainder of this paper proceeds as follows. First, a polynomial lag wheat acreage response model in Kansas is estimated. Second, estimated results, elasticities, and implications are discussed. Third, future research directions are sketched. Some specific methodological procedures are also suggested to deal with these research problems.

The Polynomial Lag Model

The use of geometric, Pascal, or polynomial lag in supply response studies is a matter of choice depending on the researchers' view of the relative importance of past values on expectations. A convenient feature of the geometric declining lag is that once the coefficient of expectation is determined the lagged response pattern follows smoothly (Nerlove 1958). The "price" that researchers pay to use geometric lag, however, is its restrictive lagged response pattern arising from the use of a constant coefficient of expectation. It is due to this restrictive assumption that I turn to the polynomial lag model (Almon). The polynomial lag is flexible enough to obtain a lagged response pattern similar to that implied by geometric lag.

In the past, risk response models typically were estimated for a small geographic area. Traill recently attempted to estimate an onion acreage response model at the national level for the first time but found the risk variable only moderately significant. At the national level, one encounters not only the aggregation problem suggested by Just but also the difficulty of including competing crops price variables in the acreage response equation. At the state or regional level (perhaps California is an exception), the price or profitability of the second best alternative crop can be effectively incorporated, and the aggregation problem becomes more manageable.

William Lin is an economist with the Economic Research Service, U.S. Department of Agriculture.

Perceptive comments and suggestions from Richard Heifner, Gerald Plato, Larry Deaton, John Baritelle, Peter Emerson, Dale Heien, and Fred Nelson are gratefully acknowledged. Needless to say, any errors remaining are the author's sole responsibility.

Preliminary empirical results of wheat acreage response in Kansas during 1950–75 are given in table 1. A second degree polynomial function is employed, since a higher degree polynomial appears to commit a larger specification error. Variables included in the equation are defined as follows: PW_{t-n} is the wheat price received by farmers in Kansas state, lagged by n years; *ESR* is the effective support rate; *EDPR* is the effective diversion payment rate; *AA* is the acreage allotment; PS_{t-1} is the price of sorghum, lagged by one year; T is the time trend (1950 = 1.0); *IC* is the index number of prices paid by farmers for production expense items, excluding livestock and poultry sectors; *SDR* is the three-year moving average standard deviation of past actual returns per acre; and t is the time period. Variables of PW_{t-n}, *ESR*, *EDPR*, PS_{t-1}, *IC*, and *SDR* are all deflated by the index of prices paid by farmers for family living and production expense items.

Following previous developments in incorporating governmental policy variables into supply response analysis (Houck et al., Just), I include "effective" support rate, "effective" diversion payment rate, and acreage allotment as three governmental policy variables. Price of sorghum lagged by one year is used as the expected price of sorghum. Time trend variable is included to capture the upward trend of wheat yields as well as the effects of wealth increases over time. To bring the input cost variable as relevant as possible to wheat production decisions, the livestock and poultry sectors were excluded from the index number of prices paid by farmers for production expense items. The ending lag

Table 1. Empirical Results of Wheat Acreage Response in Kansas, 1950–75[a]

Explanatory Variables	Conventional	Length of Lag 3	4	5	6	7	8
Constant	11,335.17	7,144.85	10,446.81	9,085.59	7,503.29	4,564.13	735.96
	(1.87)	(1.47)	(1.89)	(1.63)	(1.21)	(0.63)	(0.07)
PW_{t-1}	1,616.29	1,736.52	2,120.22	2,050.65	2,059.56	2,154.54	1,985.95
	(2.29)	(2.06)	(2.94)	(3.04)	(3.05)	(3.00)	(2.41)
PW_{t-2}	1,153.68	1,434.19	1,500.31	1,413.58	1,443.14	1,606.88	1,652.26
	(3.04)	(2.13)	(3.34)	(3.85)	(3.95)	(3.89)	(3.69)
PW_{t-3}	730.10		793.57	859.45	928.97	1,134.65	1,335.22
	(1.62)		(1.79)	(2.09)	(2.40)	(2.75)	(2.34)
PW_{t-4}	345.54			388.26	517.06	737.85	1,034.85
	(0.94)			(1.17)	(1.25)	(1.53)	(1.36)
PW_{t-5}					207.40	416.47	751.15
					(0.70)	(0.91)	(0.91)
PW_{t-6}						170.52	484.10
						(0.57)	(0.67)
PW_{t-7}							233.72
							(0.52)
ESR_t	3,490.09	3,349.23	3,834.27	3,136.94	2,835.34	2,689.36	2,299.02
	(2.78)	(2.99)	(3.61)	(2.74)	(2.28)	(2.06)	(1.46)
$EDPR_t$	−2,584.81	−2,779.18	−3,185.64	−3,281.03	−3,189.30	−2,747.44	−2,289.59
	(−3.30)	(−3.17)	(−3.97)	(−4.14)	(−3.95)	(−2.91)	(−1.68)
AA_t	0.247	0.280	0.365	0.337	0.323	0.321	0.303
	(1.94)	(2.08)	(2.89)	(2.72)	(2.52)	(2.41)	(2.11)
PS_{t-1}	−2,907.35	−2,081.27	−2,335.78	−2,168.72	−2,247.35	−2,962.13	−3,034.27
	(−2.07)	(−1.41)	(−1.73)	(−1.64)	(−1.59)	(−1.64)	(−1.48)
T_t	580.72	447.22	667.59	654.78	672.02	750.25	848.11
	(3.71)	(4.49)	(4.58)	(4.47)	(4.38)	(4.26)	(3.18)
IC_t	−154.68	−102.60	−177.88	−162.08	−153.77	−149.58	−146.48
	(−2.60)	(−2.78)	(−3.19)	(−3.02)	(−2.76)	(−2.64)	(−2.45)
SDR_t		−58.98	−95.05	−97.29	−99.36	−94.86	−82.49
		(−1.03)	(−1.84)	(−1.94)	(−1.92)	(−1.81)	(−1.37)
$\bar{R}^2$	0.681	0.808	0.790	0.742	0.738	0.750	0.745
σ_u	710.2	724.00	661.29	640.65	655.36	659.34	688.41
D.W.	2.49	2.37	2.20	2.34	2.43	2.53	2.28

[a] Figures in parentheses are t-ratios; σ_u is the standard error of estimate, and D.W. is the Durbin-Watson statistic.

coefficient or weight is restricted to zero to avoid any unreasonably sharp discontinuity in the lagged response.

The estimated results are reasonably satisfactory. All coefficients have expected signs and reasonably large t-ratios, particularly when five years is chosen as the "best" length of lag. The choice of the best length of lag can be subject to a more rigorous test suggested by Harper. According to the minimum residual-variance criterion (Theil), a five-year lag appears to be the best length of lag, either including or excluding the risk variable, SDR, in the model. Inclusion of the risk variable only improves the explanatory power moderately, although some coefficients are moderately altered. Further exploration on the measures of risk variable is needed to reach firmer conclusions of the effects of risk on acreage response.

The short-run price elasticity of acreage response with respect to the lagged market price (PW_{t-1}) was computed as 0.37 at the sample mean—virtually the same as that reported earlier by Houck et al. (0.39) and close to 0.47 reported by Nerlove (1956) for the 1910–32 period. The long-run cumulative price elasticity for all N lagged periods was computed as 0.84, again, very similar to the 0.93 reported by Nerlove (1956). The empirical results also imply that a 1% decrease in instability, defined in terms of the three-year moving average standard deviation of gross returns, would lead to an increase of 0.06% in wheat planted acreage. Had the expected risk in 1975 been reduced from the actual $21.19 per acre to the historical trend of $4.00, some additional 622,000 acres of wheat would have been planted in Kansas.

The lagged response patterns for three, four, and five years lags were shown in figure 1, of which the five-year lag appears to be the most plausible. This lagged response surface is convex toward the origin, not totally different from the geometric lag response obtained by Nerlove (1956, 1958). In fact, Nerlove's previous finding suggests that the lagged responses beyond the past sixth year become negligible, a response pattern resembling that suggested by our results. Our lagged response pattern, however, represents a dramatic departure from the pattern obtained from Just's previous work in California, which implies that wheat farmers would take twenty years in San Joaquin Valley and thirty-five years in Sacramento Valley to complete one-half of the total lagged response using "model 3" results. As evidenced in figure 1, Nerlove (1956) reports a coefficient of expectation of 0.52 for the United States, compared with 0.035 in San Joaquin Valley and 0.02 in Sacramento Valley reported by Just.

Contrary to results reported earlier by Just in California, instability estimated for each point in time during 1950–75 suggests that wheat return was considerably stabilized for the period approaching 1970, compared with the early 1950s (Lin).

Future Research Directions

There are numerous research areas that need to be pursued further if the effects of the instability on supply are to be adequately measured. The remainder of this paper focuses on some of these research needs and possible procedures.

In spite of calls for normative risk response studies, the published aggregate risk response studies all follow the positive approach wherein the supply function is estimated directly using historical time series. Yet, the positive approach cannot effectively account for the effects of changes in the decision-making environment as is theoretically possible with the normative approach. The major obstacle to the normative approach, in my judgment, are problems associated with the estimation of an aggregate utility function for producers, capital rationing by lenders, and resource fixity.

To the extent that the aggregate utility function or the trade-off between mean and vari-

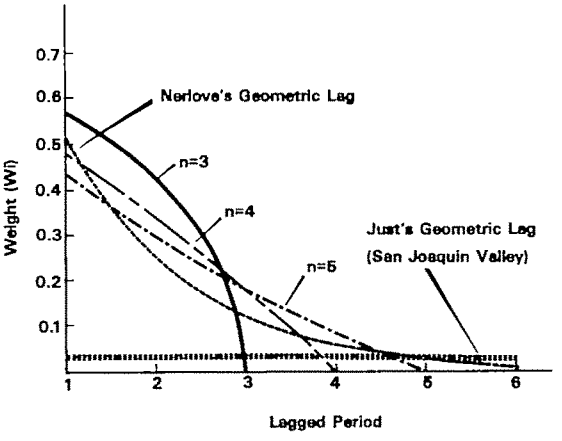


Figure 1. Polynomial lag response for Kansas wheat planted acreage

ance of return can be measured, then a regional E-V analysis would be an appealing approach to measure aggregate supply response under instability. Recent theoretical work by Keeney suggests that it is possible to derive such an aggregate utility function, provided interpersonal comparison of preference is allowed. Questions related to capital rationing by lenders can be pursued in several ways. Farmers' loan-borrowing capacities for farm operation can directly be added into the resource constraint vector. Alternatively, lenders' attitudes toward risk can be incorporated into the E-V analysis by imposing a "safety-first" constraint to the E-V frontier. Thirdly, lenders' utility functions, in addition to producers' utility functions, may be needed if the lenders possess some control on farmers' planted acreage decisions. With regard to resource fixity, there is a need to extend the static E-V analysis to a dynamic analysis so that the process of resource adjustment over time can be captured by the model.

Expectation models, such as adaptive expectation, are predicated on the premise that expected price is a function of past historical prices, "if more specific information is not available" (Nerlove 1956, p. 499). Yet casual observations remind us that producers may rely partly upon other market indicators, such as futures market price and outlook information, to form their price expectations. Recent empirical evidence suggested by Gardner that futures price, as an expected price, performs equally well as the lagged price in explaining crop acreage response further confirms our observations. This raises a question: How should we incorporate futures market or outlook information, in addition to historical prices, into the expectation model? One possibility is to convert the prior subjective probability distribution of historical prices, taken to be the weights of past prices in the estimated expected price equation, into the posterior probability distribution by integrating the expectation model with Bayesian decision theory.

An important application of risk response studies is to assess the distribution of welfare gains and losses from stabilization. Recently, Turnovsky has shown that when the assumptions of linear demand and supply equations and additive disturbances are dropped the allocation of welfare gains between consumers and producers tends to become indeterminate. Thus, specification of the demand and supply functions becomes an important issue in assessing stabilization policies.

To the extent possible, specification of functional form should be guided by economic theory. In the absence of a priori theoretical basis, existing few risk response studies have all relied upon the linear specification. Recent developments in the area of transformation of variables (Box and Cox), however, greatly widen the choice of functional forms and make it possible to determine the best form in a more rigorous and formal manner.

Economic uncertainty tends to induce farmers to favor diversification over specialization; the former generally is associated with small economic units, and the latter is commonly identified with large commercial farms. Early empirical studies suggested that stable prices encourage large-scale farming; however some agricultural economists begin to doubt whether the small family farms are able to survive in high-technology and high-risk phases of agricultural production. Is there any basic contradiction? To answer the above question, one would have to quantify the differential risk effects on farms of various scales of operation. Supply response under instability, if it can be broken down by farm size, certainly offers an important aspect of the risk effects on farms of various scales. Implications of instability on farm structure can further be drawn from this type of study.

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Considerations in Designing Stabilization Schemes

J. R. Anderson, P. B. R. Hazell and P. L. Scandizzo

Stabilization schemes have, in the current national and international debates, come to mean almost exclusively price stabilization schemes. We shall largely share this preoccupation in our paper, but it is worth considering briefly the rationale of this focus.

Economic theory, while somewhat ambiguous on the topic, is far from supportive of the need for price stabilization schemes. Axiomatic treatments of the theory of well-behaved and decentralized economies under uncertainty (e.g., Arrow, Debreu, Hanoch) lead to the conclusion that Pareto-optimal equilibria can be reached without any need of government intervention. A key feature of these analyses is to define commodities by possible states of nature as well as by their physical characteristics, so that Pareto-optimal equilibria are defined for the economy for each state of nature. Uncertainty is then only undesirable if the economy fails to make automatic adjustment from one equilibrium to another, a possibility that can only arise through market failures in either the demand for contingent claims or the supply of real insurance contracts or because of imperfect information. Thus, uncertainty is only undesirable if accompanied by market failure, and the obvious remedy is to correct these market failures rather than to remove the uncertainty itself.

Samuelson, in a rather different approach, argues that an economy in a Pareto equilibrium devoid of uncertainty cannot attain greater welfare simply through the introduction of uncertainty (unless, of course, the majority of individuals are perverse risk lovers). The conclusion in this case is that stabilization must always be desirable and that the first-best policy is to remove the source of uncertainty. Since price instability is usually the result of more fundamental sources of uncertainty, such as production risks, price stabilization is unlikely to be a first-best policy,

In overlooking these results from theory, government and international bodies are clearly responding more to what might be called the pragmatic policy approach. Proponents of this view argue that in the real world, uncertainty causes markets to fail almost everywhere. United Nations Conference on Trade and Development (UNCTAD) in various documents argues, for example, that uncertainty disrupts the orderly behavior of economic agents in a competitive economy, introducing difficulties and errors in investment and production decisions, stimulating inflation and business cycles, and increasing the risk of bankruptcies and debt default (see, e.g., UNCTAD). Arguments for developing countries are also furthered by their usual specialization in a few primary commodities for which export prices are uncertain. Uncertainty then also has a direct and highly disruptive effect on export earnings and hence on economic stability and growth and, in conjunction with low foreign currency reserves, conspires to reduce a country's ability to borrow abroad and to increase its risk of international debt default.

The policy pragmatic approach concludes that stabilization is always a good thing and the relevant question is what to stabilize and how. Price stabilization is a viable policy not because it is necessarily (if ever) a first-best policy but rather because it is one of the few forms of market intervention available to a government or international agency. However, alternative stabilization policies are often available depending on the policy goals, for example, international compensatory finance schemes, buffer funds, or producers' income insurance schemes, so that the current preoccupation with price stabilization must have yet a further underlying rationale. One rationale is suggested by the existing literature

Jock Anderson is an associate professor, University of New England, Armidale, Australia, and Peter Hazell and Pasquale Scandizzo are economists with the Development Research Center, World Bank, Washington.

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on applied welfare economics, which, while increasingly indeterminate, does tend to show that producers as a group are, on average, the main beneficiaries of price stabilization (see Turnovsky for a recent review). Possibly, those concerned with the development of predominantly agricultural economies are hopeful of capturing these welfare gains from the international markets.

However, policy makers should not be too easily seduced by the apparent gains and feasibility of price stabilization schemes. There remain important questions about the distribution of gains and losses from stabilization schemes that have yet to be resolved. These concern not only the trade-offs between consuming and producing interests, both within and between countries (a favorite topic of economic analysts), but even the distribution of the gains and losses within these groups themselves. Lipton, for example, argues that price stabilization of major food commodities tends to stabilize rural wages and real incomes for poor rural families dependent, or partly dependent, on wage earnings; but, given the usual sorts of magnitudes for demand elasticities, it will tend to destabilize the revenue of farmers with a marketed surplus. He concludes that price stabilization may have desirable intrarural income distributional effects in countries with a high proportion of subsistence farmers but have less desirable effects in countries with more advanced agricultural sectors.

When production variability is the source of price uncertainty, the consequence of stabilizing prices for revenue stability depends crucially on the price elasticity of demand; revenues are also stabilized when the absolute value of the demand elasticity is 0.5 or less but are destabilized otherwise (Tomek, p. 77).[1] Policy makers in countries producing commodities for export in more elastic markets than this might well want to consider the inherent trade-offs between price stabilization and the stability of producers' incomes and national export earnings. If the latter are of primary interest, simple price stabilization may well be an inappropriate goal.

While many unresolved considerations exist in determining the appropriateness of price stabilization measures, we turn now to a discussion of considerations to be taken into account in the design of such schemes. We focus on commodities that can be stored and assume price stabilization is to be achieved through a buffer stock agency (BSA). Our discussion will undoubtedly be incomplete in touching on all the key considerations, and we plead guilty to emphasizing those considerations of most interest to us, as well as those that we consider to have been neglected in the past.

A highly pertinent question in the design of any price stabilization scheme is the price, or range of prices, at which market prices are to be stabilized. There are two tricky issues here. In the first place, longer run market efficiency will only be sustained in a decentralized economy if prices are still allowed to retain their role in providing signals to producers and consumers in allocating their resources. While a prime purpose of a stabilization scheme is to remove unnecessary noise in the price signal, the BSA must still set, and indeed adjust, its prices to reflect structural changes in the economy. Given the many sources of price uncertainty in the real world (production risks, business cycles, demand fluctuations, etc.) and frequent structural changes in technology and demands, the BSA is faced with an analytical problem that is likely to be beyond the ken of even the most able econometrician. A second issue concerns the size of the stocks the BSA can carry. Given existing costs of storage and money, any BSA will face a real nonzero probability of running out of stocks in some years. For a given storage capacity, this possibility increases as the desired range of price variability is narrowed through BSA operations, so that the choice of a price band cannot be made independently of the allocated resources of the BSA.

But the problem of price setting does not end there. Any institution that has a major price-setting role will rapidly find itself confronted by pressures from special interest groups. When demand for the commodity in question is inelastic, producers undoubtedly see the value in coercing the BSA to raise its average selling price, even at the expense of accumulating surplus stocks. At the international level, producing countries may see the establishment of world buffer stock schemes as a forum for improving their average terms of trade. For example, the UNCTAD proposal for an Integrated Commodities Program claims, as one of its stated objectives, the "Establishment and maintenance of commod-

[1] Tomek reports his results in terms of the price flexibility coefficient F. Our interpretation assumes that $1/F$ is the demand elasticity, which is only strictly true in the absence of cross price elasticities.

ity prices at levels which, in real terms, are equitable to consumers and remunerative to producers, taking full account of the rate of world inflation, the need to provide incentives for adequate investment in commodity production, the depletion of non-renewable resources and the need to keep the prices of natural commodities competitive with those of their synthetic substitutes" (p. 3). While such objectives may well be justified,[2] it is clear that the establishment of BSA's requires a serious resolution of their political and economic roles and responsibilities and especially of the interests they are to serve.

Yet a further consideration in determining the desired price level has been raised by Hazell and Scandizzo. They argue that, if producers facing risky production allocate resources on the basis of anticipated prices and yields that are formed independently of each other, competitive markets can be inefficient. Social welfare can then be improved by establishing a BSA that has sole purchasing power with producers and that pays producers a lower price than the one it sells at to consumers. The optimal size of the price wedge can be determined as a function of the elasticity of demand and the coefficient of variation of yields.

Although it has generally been ignored in both theoretical and empirical work, another key consideration in designing BSA's is that producers modify their supply behavior in response to the stability induced by a BSA. The usual reasoning here is that producers are averse to risk and that, if a price is stabilized, they tend to produce more of the formerly risky commodity. Indeed, such risk-averse behavior has seemingly been captured in empirical models of risk-responsive supply of agricultural commodities—most notably by Just. Moreover, our own work employing his methodology has confirmed such risk-responsive supply behavior in enterprises as diverse as grain and vegetable production in northern Mexico and jute production in South Asia. Such effects appear pronounced and statistically significant. Thus, they are also bound to be economically significant in the design of a BSA, since any producers' gains induced by stability may soon be competed away through their own responsiveness to the new environment.

Proponents of BSA's often seem to assume away the existence of private stockholdings in commodity markets. Yet these may be quite substantial and, prior to the introduction of a government BSA, may play an important role in bringing some stability to market prices. It is clearly important to know how private stockholders will respond to a government BSA. If, as is likely, they reduce their stocks, the BSA will require additional capacity to offset the destabilizing effects of reduced private stocks. Of course, if private stockholders previously acted in a speculative and destabilizing way, the introduction of a BSA may be accompanied by a bonus gain in stabilization as speculative behavior is reduced.

A final consideration is that of risk pooling. Two potential sources of risk pooling exist: across commodities and across regions or countries. The essential principle here is that the size and cost of a BSA can be reduced without any loss in its price stabilization role by exploiting risk-pooling opportunities. The gains are obvious in the case of geographic risk pooling. If producers of the same commodity in different regions or countries face less than perfectly correlated (+1) production risks, offsetting output fluctuations will lower the necessary size of the stocks required to achieve a given level of price stability. Geographic risk pooling provides a good argument for establishing BSA's at the multinational level.

Risk pooling over commodities can serve a similar role if they are close demand substitutes and if their yield risks are not perfectly correlated. Commodities that are not good demand substitutes offer little advantage to a BSA, but they can be a good basis for risk pooling in buffer fund schemes, such as proposed by UNCTAD.

[2] Prebisch and Emmanuel have demonstrated that developing countries are disadvantaged in competitive international trade—the so-called "unequal exchange" theory. This view is also popular with Marxists, though their rationale is based on the labor theory of value (Mandel).

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Theoretical and Empirical Possibilities for Determining the Distribution of Welfare Gains from Stabilization

Richard E. Just

The general question of price stabilization is one of those problems in economics where the complexity of the issue is far beyond the theoretical and technical capabilities we now possess for analyzing it. Consequently, analytical studies of stabilization policy have been reduced to examination of only one or a few important aspects of the problem (at a time) while disregarding others. As a result, much of the theoretical work on price stabilization has been overlooked by empiricists and those involved directly in the policy-making process.

However, these theoretical studies, simplistic as they may be, can often illuminate some disastrous pitfalls in empirical research. Perhaps the results of a single theoretical paper can invalidate or cast great doubt on the conclusions of a host of expensive empirical studies. In point of fact, this paper discusses several noteworthy examples. In such cases, a bit of analytical work in advance or some better communication between theoreticians and empiricists could avoid a great deal of both effort and expense.

This paper contributes to this latter end; that is, I would like to briefly assess the theoretical literature dealing with commodity price stabilization, summarize the major results, point to their implications for empirical research, and then discuss the extent to which these findings have been considered in empirical research.

Nonlinearities

Consider, first, the implications of the theoretical literature on price stabilization relating to nonlinearity. Papers by Turnovsky (1974b) and Just et al. (1978) are of particular interest in this respect. Using special cases of assumptions similar to those used under linearity by Massell, Turnovsky has pioneered a methodology for examining the role of nonlinearity in determining the gains and distribution of gains from price stabilization. Further paralleling the work under linearity by Hueth and Schmitz, the Just et al. paper extends Turnovsky's methodology into a framework of international trade.

The framework of these papers is quite restrictive in that instability can only be assumed to arise from one sector at a time. Nevertheless, the results of the work carry considerable implications for empirical research. Contrary to the earlier work under linearity, Turnovsky concludes for a closed economy that "the desirability of price stabilization for either producers or consumers *does not depend upon the source of the price instability*, but only upon the shapes of the deterministic components of the demand and supply curves" (1974b, p. 24). Similar results developed by Just et al. (1978) with respect to importing and exporting countries also demonstrate that shapes of supply and demand curves are critical in determining qualitative effects of stabilization.

Just et al. (1977) further demonstrate that an excessive degree of nonlinearity is not necessary to obtain a reversal in who gains and who loses over the case of linearity. Specifically, they show, for the range of elasticity estimates forthcoming from most econometric studies of grain supply and demand, that a switch in specification from linearity to log-linearity with commonly accepted elasticities can be sufficient for such a reversal depending on the source of instability.

What are the implications of these results for empirical and simulation studies of stabilization? The theory implies that any empirical study that does not adequately investigate

Richard E. Just is an associate professor of agricultural and resource economics, University of California, Berkeley.
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functional forms may, in fact, be determining results through arbitrary specifications and assumptions. In point of fact, "approximation in the range of relevancy" is not sufficient as in most econometric problems (e.g., price forecasting), since standard welfare measures depend on the shape and position of supply and demand curves outside the range of normal price variation.

To what extent have these considerations been made in empirical stabilization studies? Nonlinearity, of course, is a problem that has plagued econometricians for years. The usual empirical or simulation approach, which has been continued in stabilization studies, has been to simply specify a linear or log-linear form. As examples (although these studies are not to be criticized more than others), I cite Cochrane and Danin; Johnson and Sumner; Sharples, Walker, and Slaughter; and Zwart and Meilke. Hence, simplistic as the theoretical studies may be, they lead to great reservations concerning use of this empirical work in applied welfare analysis; that is, since the theory suggests that reversals can take place as one switches between the two popular specifications, one cannot be sure of even the qualitative results of such empirical studies. The true degree of nonlinearity may be greater or less than that suggested by log-linearity. These conclusions are supported by the empirical work of Reutlinger who, in using crude piecewise-linear demand curves, concludes that "the storage impact on gains and losses by consumers and producers is particularly sensitive to the assumed shape of the demand function" (p. 8).

The Form of Disturbances

Another matter of specification that theoretical studies have shown to be important is the way in which random disturbances enter the problem. The early work, e.g., Massell and Hueth and Schmitz, was based on additive disturbances in supply and demand. Turnovsky (1976) has since argued, however, that multiplicative disturbances in demand are much more plausible than additive ones, and other authors such as Hazell and Scandizzo have also adopted multiplicative random disturbances in supply. Although these two alternative stochastic assumptions are admittedly simple, the theoretical literature has been able to argue on the basis of the results that "the [welfare] distributional conclusions are highly sensitive to the form of stochastic disturbance assumed" (Turnovsky 1976, p. 134). For example, one can compare the Just et al. (1978) results with those of Hueth and Schmitz with linearity.

Again, as with respect to nonlinearity, we must conclude that an empirical study that specifies the form of disturbance a priori may be influencing not only the quantitative but also the qualitative nature of the results obtained. As Turnovsky concludes, "unless the policy maker has reliable information on this question, any stabilization policy may have undesirable effects on the group it is intended to assist" (1976, p. 145). So, even though very simplistic cases are considered in the theoretical literature, the cases cannot be dismissed a priori and, hence, the negative results (if not the positive) have major implications for empirical research.

To what extent have these considerations been made in empirical studies of stabilization? Unfortunately, very little if at all. Representative studies such as those mentioned above all seem to arbitrarily assume either additive or multiplicative disturbances usually depending on whether linearity or log-linearity is assumed. Again, as with nonlinearity, it must be concluded that little confidence can be placed in empirical and simulation studies until the form of random disturbances is adequately investigated.

Risk Response

Consider further the implications of risk response for price stabilization policies. As price stability is attained, risk can be greatly reduced. But as risk is reduced, risk-responsive farmers may increase supply (Just 1975b) and, as a result, expected profits will increase by more than the standard Massell and Turnovsky risk assumptions would indicate. Also, buffer stocks could accumulate indefinitely at stabilized prices that would otherwise be reasonable (Just 1975b). Similar arguments can be made with respect to risk-responsive consumers as evidenced by the work of Lutz and Newbery.

Again, the theoretical results tend to be negative and imply that estimates of gains from stabilization may be seriously biased downward (under risk aversion) and that any efforts to determine an optimal stabilization

policy (e.g., normal price) may be thwarted when risk response is not considered.

Examination of the empirical stabilization literature reveals that risk response has been considered only rarely even though risk consideration in applied econometrics is becoming quite common. The traditional stabilization studies that have used econometric estimates of supply and demand have almost universally ignored risk response. Hazell and Scandizzo, however, have been able to treat risk response by using a mean-variance programming approach for agricultural supply. Although their model is more restrictive in behavioral assumptions than other econometric studies of stabilization, their results are consistent with those of the theoretical studies cited above and raise further doubts about other empirical work. In fact, they conclude that "the potential welfare gains to be had from optimal intervention policies are surprisingly large, in fact far greater than might be anticipated" (p. 18) in the case where risk response is considered.

Trade Controls and Institutional Considerations

Some other factors that, no doubt, play a considerable role in international grain marketing relate to trade controls and institutional structure. In this respect the papers by Bieri and Schmitz and by Just et al. (1977) are interesting since they imply that trade restrictions and institutional structure can significantly affect the outcome of stabilization policy. For example, Bieri and Schmitz show that, when the source of instability is external, the importing country prefers price stability when trade is restricted by tariffs but not when trade is restricted by marketing boards. These results are contrary to those under competition developed by Hueth and Schmitz and, thus, suggest that institutional structure plays a decided role in determining even the qualitative effects of price stabilization.

The paper by Just et al. (1977) considers the effects of such controls as variable trade levies on price stability and specifically investigates the way in which variable trade levies have apparently been used in the Common Market to export instability and thus maintain stable domestic prices. The results suggest that such a policy in importing countries causes the role of nonlinearities in the exporting countries to become even more crucial in determining the welfare effects of stabilization than without trade levies, while nonlinearities in the importing countries are no longer important.

Again, although each of these papers uses a rather simple theoretical framework, the implications of the results must be considered in empirical problems where market power and trade restrictions may play a role. For example, in problems like wheat price stabilization where large U.S. grain trading companies and institutions such as the Canadian Wheat Board dominate international trade, one must seriously question the extent to which gains from stabilization might be affected by market power among traders.

In examining the empirical stabilization literature, one finds that these considerations have not been made (again, for example, the representative empirical studies above may be cited). Thus, given that institutional and trade factors can strongly influence the qualitative welfare effects of stabilization even in a simple model, one must seriously question the studies that ignore these factors in attempting to find quantitative estimates of welfare impacts.

Private versus Public Storage

Another area in which empirical work has apparently been weak relates to the role of private storage. For example, the empirical work of Cochrane and Danin, Reutlinger, and Sharples, Walker, and Slaughter has recently been criticized by Helmberger and Weaver because it ignores the stabilizing effect of private storage as well as the reaction of private storage supply to the imposition of a public storage program. As Helmberger and Weaver show, the distribution of welfare gains from price stabilization may be much different when these reactions are adequately considered.

Since Helmberger and Weaver have dealt with this point at some length, it suffices to say that there has been a disturbing lack of private storage considerations in empirical studies of price stabilization. In particular, given the empirical research that verifies private storage supply response (e.g., Lutz), one must view most empirical work thus far with some degree of skepticism.

Choice of Stabilization Policy Controls

Another issue for which the theoretical literature has made some interesting suggestions relates to the use of alternative stabilization

policy controls. For example, empirical work has generally considered only arbitrarily selected rules for buffer stock transactions based on price bands, quantity bands, etc. Theoretical investigation, however, has indicated that economic efficiency leads to some buffer stock transactions even at near normal prices and that a strict price bound should not be enforced in periods of either extreme shortage or extreme surplus (Just 1975a). Rather, a variable stock policy based on current prices should be used to attain an efficient trade-off between welfare costs associated with price variability and storage costs associated with buffer stock variability. While these results are derived in a simplistic framework, the more recent empirical work of Cochrane and Danin and of Zwart and Meilke has indeed found that such policies are preferable to storage policies of more traditional forms (although, again, several important aspects of the problem are not considered in their work).

Moreover, one must consider the possibility that controls other than buffer stocks provide a more economically efficient means of attaining stable prices. For example, Turnovsky (1977) shows that publicly announced forecasts can have a price-stabilizing impact. Thus, for example, federal funds may be better spent on improving U.S. Department of Agriculture forecasts than on operating a buffer stock. Other prospects are provided by insurance and by futures market operation and regulation. Yet, another possibility involves the use of variable trade controls in the same sense as considered by Just et al. (1977). By imposing variable trade levies, it is possible, at least in principle, for a small country to completely stabilize internal prices at normal levels without incurring storage costs. This may be the cheapest form of price stabilization for (small) developing countries; yet related empirical studies (e.g., Reutlinger) have not considered this alternative. The possibilities for exporting instability from the United States with this mechanism are more limited, however, because extremely low prices may be obtained for U.S. exports in years of excess production and, furthermore, trade retaliation may be induced.

The Surplus Concept Used for Measuring Welfare Impacts

Finally, the use of producer and consumer surplus has been heavily criticized over the years and, while I do not adopt the philosophy that "consumer surplus is questionable, therefore we should not do anything," I believe we should seek better understanding and more competent application of the surplus concept in use. For example, the standard assumption of perfectly elastic input supplies is surely not justified in agriculture, so what does producer surplus associated with grain supply mean? How should surplus measures be aggregated over time to correctly estimate long-term effects of stabilization? How should comparisons of producer surplus associated with risk-responsive supply curves be interpreted? Should different interpretations be attached depending on whether risk response is due to technical efficiencies or producer preferences? These are questions that require clear answers before competent empirical analysis can be performed. The answers are not beyond our grasp. Indeed, several of these questions have been addressed in recent unpublished work by Hueth, Just, and Schmitz; and more answers promise to be forthcoming shortly.

Conclusions

I will conclude with some comments about the perspective with which theoretical and empirical studies should be viewed in the context of applied policy analysis. As this paper has attempted to show, theoretical investigations can be useful in illuminating the potential consequences of some particular aspects of a problem. Since one is usually not able to rule out the same phenomenon in a more general, real world situation, the results can be useful even when the theoretical work is based on considerable simplifications and abstractions. Hence, models intended for theoretical investigation need not be forced into the complexities of "real world" assumptions in order to serve their purpose but must simply include the essential but tractable aspects of a particular problem.

Empirical studies, on the other hand, are usually efforts to derive some quantitative estimates relating to the impact of present or proposed policies and as such are by design an effort to deal with a real world situation. In this context one must have great concern for the aspects of the problem that plausibly have an important influence on results. Theoretical study in a variety of abstract situations is a useful and relatively inexpensive way of determining some important aspects that should

be considered in designing an empirical study. Thus, theoretical work should not always be viewed as an attempt to answer important policy questions but must also be recognized as a means of identifying important needs in empirical research.

With this approach in mind, I have attempted to discuss some of the more important implications that the theoretical literature on price stabilization holds for empirical research. I view the topics specifically addressed here as particularly important because I feel that we now possess sufficient econometric and empirical skills to explicitly consider the associated problems. There are, of course, a number of other aspects of the problem that should also be considered but that were of less importance for this paper due either to the nonconsequential nature of the results or the lack of adequate theoretical results thus far. For example, Turnovsky (1974a) argues that lags in decision making and serial correlation in disturbances should also be considered, but his theoretical results do not differ qualitatively from others, nor does empirical consideration cause great difficulties.

Some less tractable problems, which may also be important in formulating stabilization policy, include the effects of speculation and the interactions with other economic sectors in a general equilibrium context. For example, Peck argues that the existence of a futures market has important consequences for price stability, which should not be ignored in developing price stabilization policy. From another viewpoint, Caves argues that flexible exchange rates should be adopted when macrolevel instability is due to foreign sources. To the extent that exchange rates affect grain trade and price stability, the interaction of exchange rate stability with commodity price stability must be considered in developing price stabilization policy.

Even more disturbing complications arise when one considers the optimal interaction of production and storage policy in a general equilibrium context of international trade: For example, Feder, Just, and Schmitz show (contrary to both the partial equilibrium case and the general equilibrium case without storage possibilities) that an exporting country should respond to greater price instability by increasing production and reducing storage. These results suggest that production policy should depend critically on the storage policy that is adopted and that the gains from buffer stock stabilization may be strongly influenced by whether or not production policies are adequately coordinated with storage policies. A sufficiently general empirical approach to investigate these kinds of propositions, however, appears as of now to be somewhat beyond our grasp.

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Toward a Philosophical Basis for Community Development
(Donald M. Sorensen, Colorado State University, Chairperson)

The Creation of "Truth" by Social Scientists and Planners: Assumptions, Decisions, and the Negotiation of Reality

Jerry A. Moles

Hermann Hesse (p. 42) once wrote a short story in which God sent a flood putting an end to a bloody World War. The last European was struggling in the flood waters when an ark appeared under the command of an aged patriarch named Noah and the unfortunate man was hauled on board. The crew of the ark was composed of persons from every ethnic group on earth. During the voyage each was called upon to demonstrate his or her skill. Finally, the time for the European to perform came, and he informed his arkmates that he was skilled in the use of his intellect in solving the ". . . great problems on which the happiness of mankind depends."

Noah was impressed, " 'The skill that brings happiness is certainly more important than any other. Just tell us what you know about the happiness of mankind. We shall all be grateful.' "

Up until then the European had been haughty and self-assured. Now he seemed at a loss.

" 'It's not my fault,' he said hesitantly, 'but you still don't understand. I didn't say I knew the secret of happiness. I only said that my intellect is working on certain problems the solution of which would promote the happiness of mankind. Such work takes a long time, neither you nor I will live to see the end of it. The problems are knotty and many generations will continue to ponder them.'

"The audience listened with mounting perplexity and distrust. What was the man saying? Even Noah averted his eyes and frowned.

"The Hindu smiled at the Chinese. When the others could think of nothing to say, the Chinese spoke up. 'Dear brothers,' he said most affably, 'this white cousin is a joker. He is trying to tell us that his mind is working on something which our great-grandchildren's great-grandchildren may or may not live to see. I suggest that we applaud him as a joker. He says things that none of us can quite understand, but we all suspect that if we did fully understand them they would make us laugh and laugh and laugh.' "

Social scientists are in ways like the European. We are interested in human happiness; we speak of the quality of life, personal satisfaction, sense of security, and freedom from need. We use our intellects to assist others in reaching these objectives. We expect to spend much of our lives in the quest of ways to increase happiness while knowing that we may be unsuccessful. As a consequence we run the risk of being called the joker. Our explanations, methods, and research techniques often do not provide adequate answers to many problems of pressing human concern. As Greer notes, "We have at best crude approximations of measurements for such variables as anomie . . . sentiment, attitude, and the like. Yet we have theories that hypothesize invariant associations of these among themselves and with other aspects of behavior. We imagine the 'felicific calculus' with units of happiness, but in practice we use crude questions for a crude concept" (p. 129).

We run the risk of being called the joker when we ignore many of the limitations that

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Jerry A. Moles is an assistant professor in the Department of Anthropology, University of California, Davis.

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exist in scientific inquiry and in the sharing of research results with policy makers, planners, and administrators who make decisions affecting our lives and the lives of others. I would like to discuss some of the limitations inherent in the scientific approach to the study of human behavior and suggest ways in which we can compensate for these shortcomings.

Science and in specific the social sciences constitutes one of the many subcultures in western culture. For our purposes culture may be defined as human knowledge. This is similar to the idea proposed by Boulding (1956) in which he conceptualized culture as images of ourselves and our surroundings. Science is a body of knowledge and one of the many methods that can be used to gain an understanding of the world. It is a powerful tool when applied with skill and insight, but science, like any other approach to understanding, has its limitations. I explore some of the ideas that have been developed concerning the nature of knowledge and relate them to social science inquiry and the uses of social science in the solution of human problems.

Knowledge is reality. What we know, our percepts and concepts, beliefs, values, skills, awareness of ourselves and others, and awareness of our environment constitute our reality. What we know is what we are. I know what I am by knowing my relationships with all other persons and things, past and present. I know there are many things I do not know, and this too is a part of my reality. Even the things I do not know are interpreted on the basis of the things that I do know. I know there are other realities. I know that I will learn about the realities of other people, but I can only interpret them on the basis of my reality, on the basis of my knowledge, because that is all that I have. I cannot share your experience, but we can experience things at the same time and place. You can experience me and I can experience you. I can tell you about my experiences, but my telling you of my experiences does not allow you to experience them. You can only interpret my experiences on the basis of your own experiences. As both Hume and Russell have shown, knowledge is ultimately derived from individual human experience.

Knowledge is "truth." While we may only be sure of our own death, there are other things which we accept as true. We ignore the philosophical complexities, receive information from interactions with the environment, and place our faith in this information. Of course, we know things that are false from our point of view, but the knowing that they are false is for us a "truth." We may erroneously accept a falsehood as being true but, until we discover that it is false, it remains true for us. In this sense some philosophers claim there is no false information, there is just information.

Knowledge is an adaptive "tool" and is more highly developed by homo sapien sapiens than by any other species. It is used to guide behavior and to interpret the behavior of others. Our ways of knowing permit social intercourse and communication. We use information to focus our attention on some aspects of the environment while ignoring other aspects. We fear the unpredictable, we fear chaos, and we continually create new knowledge to interpret and assign meaning to the present and to anticipate the future (Garfinkle, Goodenough, Mehan and Wood). Novak in his discussion of knowledge as culture notes, "Experience rushes in upon us in such floods that we must break it down, select from it, abstract, shape and relate. . . . A culture is constituted by the meaning it imposes on human experience . . . even the most solid and powerful social institutions, though they may imprison us, impoverish us, or kill us, are fundamentally mythical structures designed to hold chaos and formlessness at bay . . . culture begins and ends in the void" (p. 23).

Knowledge is also adaptive in the sense that new knowledge is created in the attempt to solve problems. We apply our energies to problems and develop new ways of viewing certain aspects of the environment. As a result, increased specialization is possible. As Simpkins notes, there is an increase of information with the development of occupational specialization. In the past when farmers served as their own blacksmiths, veterinarians, bankers, etc., there was a limit to the amount of knowledge that could be developed and brought to bear on any single problem. As people left farming and specialized in these areas, new knowledge was created and important breakthroughs occurred. A part of the creation of new knowledge includes the development of ways in which to search for knowledge. Scientific methodology has been one result of the search for new information.

Knowledge tends to be created at a conservative rate. Wallace points out that two major problems must be solved by all people. We must replicate uniformity and organize di-

versity. We replicate uniformity in order to make our behavior intelligible to others and to interpret their behavior, to use the skills and knowledge that have proven successful in the past to meet the needs of the present, and to reduce the need to continually learn de novo from new experiences or, said another way, to reduce the high cost of new information. We organize diversity so that we can interpret new situations, know how to handle new conditions, and learn from mistakes. Consequently, we try to limit the rate of change in knowledge to a level that we can control. It is often to our advantage to maintain the status quo if we are in a satisfactory position. In some cases when we are not in a satisfactory position, we do not attempt to change because the circumstances in which we exist are at least predictable if not comfortable. We are often amazed in development programs when farmers refuse to adopt a new crop that we believe would be advantageous. If they have had no experience with the new crop and cannot anticipate their return, they may well reject the offer. The cost of the new information is too high in that they must risk their livelihood to determine the yield of the new alternative.

Knowledge systems tend to be conservative in another way. Levi-Strauss pointed out in his study of mythology that knowledge systems tend to be circular and closed. It is possible to start at any point in a set of myths that describe and explain some phenomena and eventually work back to the starting point. Any set of knowledge, including science or any discipline, can be viewed as a type of mythology in that it is a set of interrelated abstractions used to account for certain kinds of phenomena. Generally, each of us accepts our view of the world as adequate at the moment for describing and explaining our world. Those things that we cannot describe and explain are often labeled as unimportant and not worthy of the efforts required to learn about them. If circumstances were otherwise, we would make the effort. While it is true that we continually search for new information in attempts to solve problems and learn from experience and that there is always a degree of novelty in behavior, learning is always based upon knowledge previously accumulated. Furthermore, we often ignore information that cannot be related to what we presently know because we have not learned to identify it, and consequently it falls outside of our range of awareness. We do not break the circle of understanding but rather continually expand it maintaining the integrity of its boundaries. We are victims of our past and cannot disassociate ourselves from experience.

In science we close the circle by calling what we are unable to account for the unknown and control the mysteries of the universe in this manner. In a sense, the concept of the unknown is a category related to the environment even though it is a residual one. We often say that the purpose of science is to make the unknown known and take comfort in this view; however, the unknown we speak of is delimited by present knowledge and the realm of discourse selected. In statistics, the explanatory circle is closed by calling unexplained variance a measurement error, but it is difficult to explain why it is an error or how to correct such an error. As noted earlier, we seem to have a special abhorrence of mystery and the unknown; we do not like not to know and as a consequence are very inventive in our attempts to close our conceptual circles. By keeping these circles closed, however, we reject potentially useful information.

Knowledge and thereby reality and "truth" are human creations. Knowledge is derived from experience and is created as we attempt to solve problems. Even though we have learned concepts that were developed in the distant past, they are only meaningful when applied to the present in which they are learned and related to information gained from experience. Furthermore, as Wagner suggests, when existing categories are applied, things in the present are made equivalent to things in the past and consequently this act of categorization is creative. After all, we have never been in this present before nor will we return. When new categories are created to interpret the environment, things that have never existed are invented. When we conceive of things that have never existed and make them occur, we have created reality. In science, we create the reality we report upon. The reality we "discover" is in part determined by the conceptual approach selected and the operational definitions or measurement techniques created to represent theoretical concepts and in part by the phenomena selected for study. For example, in quantum physics it is possible to view light either as waves or as particles, depending upon the measurement technique used and the research question at hand. We create variability by placing discrete entities into a single category

and looking at two or more of them using one or more additional categories as variables.

We create reality each time we select among alternatives. Regrettably we have but one life to live in this plane of existence, and the present is the eternity in which we all must live. When we select one television program over another or over mowing the lawn, we have created our reality. Moreover, in the social sciences we create additional realities to "explain" the realities we select and create. Economic theory holds that we select among alternatives in a "rational" manner and that the things selected have more "value" than the things not selected. We assume a value can be placed on the alternative selected and imply that a lower value is placed on alternatives not selected. The concept of opportunity cost was created to "explain" the selective creation of reality. Furthermore, the concept closes a rather obvious conceptual circle.

Part of our reality is created privately, and we do not attempt to share it with others. Other aspects of reality are negotiated with others and determined through consensus or at least an agreement not to disagree anymore. We will never know the perceptions and conceptions of another person. If I could see through your eyes, what I normally see as white might appear to be green. If you could see through my eyes, what you might see as white might appear to be purple. Nonetheless, we have both agreed to call the green and the purple white so we will concur that your shirt is white. Such consensus is usually referred to as intersubjective agreement. What we call the "objective" approach in science is based upon a number of negotiations that have transpired over the years in conversations, journals, and books. We have accepted certain standards for scientific endeavors or have agreed that further discussion is not productive. "Objectivity" is just another set of intersubjective agreements.

Some people have greater skill in negotiating reality and "truth," they may have greater power, or they may have considerable influence and consequently have a strong hand in the determination of reality based upon intersubjective agreement. Nietzsche once wrote, "*the real philosophers are commanders and legislators.* They say, 'It *shall* be thus!' They determine the 'whither' and the 'to what end' of mankind—having the preliminary work of all the workers in philosophy, the overpower of the past, at their disposal. But they grope with creative hands toward the future—everything that is and was becomes their means, their instrument, their hammer. Their 'knowing' is *creating*" (p. 135). I would add that many others play similar roles including businessmen, scientists, teachers, governmental administrators, etc.

We are often unaware of our creation and negotiation of "truth" and reality. We accept what we have learned and use it creatively without question. We accept social order including interpersonal interaction and economic transaction as "natural." Yet as Berger and Luckmann point out, "Social order is not part of the 'nature of things,' and it cannot be derived from the 'laws of nature.' Social order exists *only* as a product of human activity. . . . Both in its genesis . . . and its existence in any instant of time (social order exists only insofar as human activity continues to produce it) it is a human product" (p. 52).

We now return to an issue raised earlier, the limitations of science in the study of human behavior and in communicating research results with other people. I first focus attention upon the scientific study of behavior. Any social science approach is used like all other knowledge systems to reduce the complexity of the environment. Human behavior is a continuous stream that occurs day after day, and we cannot hope to deal with all of its variety and richness. As a result, we only deal with limited aspects of human activity. When specific areas of inquiry are selected, it becomes obvious that an increased number of categories are required to account for the variability encountered. After all, science advances with increased specification. As specification increases, it becomes more difficult for any researcher to remain aware of much of the behavior of the people under study. Consequently, any research report that meets contemporary scientific standards usually tells very little about a wide range of activities that may influence the specific behavior under investigation. For example, Schultz notes that some growth models in economics have treated institutions as givens or as a part of the "state of nature," while others have treated institutions as independent of economic change.

Economists have studied the management of capital, labor, and technology on farms while ignoring the social structure that supports agriculture. Anthropologists have studied the social structure of rural communities while

ignoring the economic aspects. It is clear, however, that we cannot account for economic behavior by the study of economics alone and we cannot account for social structure by the study of social structure alone. Even if economists, anthropologists, sociologists, etc., worked together, we would never be able to adequately describe and explain the behavior of farmers or anyone else. We view brief instances of their lives, but they live their lives on a full-time basis. While one objective of science is to generalize, increased specification reduces the ability to do so because of our limited capacity to control information. Also, the number of specifications are limitless; they are created by scientists and are limited only by the creativity of their minds. We are caught in a double bind. To have confidence in our results we must increase specifications, but in the process we lose sight of the subject of inquiry, people living in a particular time and place.

Social scientists have tended to follow the scientific paradigms created by the physical scientists. Becker notes that this narrow positivist approach that seeks to analyze separate and distinct aspects of behavior was bound to fail. Because of the limited realm of inquiry in physics and the degree of control a physicist can exert over the phenomena, the positivistic approach is plausible; however, as Ritchie notes, the approach has encountered serious difficulties in biology. Given the complexity in human behavior, these difficulties are compounded in social inquiry. Boulding comments that at the level of understanding human behavior "it may be doubted whether we have as yet even the rudiments of theoretical systems" (1968, p. 9). Wittgenstein may have been correct at least for the foreseeable future when he suggested "that even after all possible scientific questions have been answered, our problems of existence have not even been touched upon" (p. 6.52).

Despite the limitations in science, we remain in the business of the creation of social "fact." It can be argued that social science works and I agree. We create "truths" in which we can have a degree of faith. Social science works best, however, when the "truths" discovered are passed to nonscientists who have the power to construct social realities. Let me explain. We create approaches based upon theory, method, and the phenomena studied. As would be expected, a close congruency is created between disciplines and the environment. In recent history as the practitioners of the disciplines, especially the economists, became more proficient, the information created was used in government and business. What began as academic discourse became a working culture used to guide decisions in important sectors of society, thereby increasing the congruency between scientific approaches and the social and economic environment. Consequently, the descriptive and explanatory powers of social science increased. The view that science works best when the categories created become part of the knowledge used by persons in positions of power is supported by experiences in developing nations. Our descriptive and explanatory growth models work much less well in the third world.

I now turn attention to some of the limitations present in communicating results with policy makers, planners, etc. All social scientists specialize in one narrow aspect of behavior, and the advice we give is based upon a rather narrow range of data. Policy makers and decision makers, however, demand generalizations; they want to create programs for all farmers, all workers, etc., and expect social scientists to provide valid information concerning a broad population. These decision makers may have had very different experiences than have scientists, may have created different realities, and may be unaware of the fragile base of social science. Furthermore, they want information immediately so they can get on with the job. Consequently, we have little time to negotiate a reality concerning the limitations of what we know and its relationship to the program envisioned. There is a jump in levels of abstraction from the specific data developed by scientists to the generalities used by planners, and the relationship between the specific and the general is often tenuous. Nonetheless, the "truth" we create is used and reinterpreted many times. Policy makers pass the information on to program administrators who, in turn, pass it along to the population for whom the program was developed. What started as specific information based upon scientific inquiry becomes a social reality and, in some cases, it is difficult for the scientist who created the information to recognize the results of his handicraft.

Scientists are often unaware of their blind spots when they do give advice to policy makers. As Barkley notes, "Too often, the economist has been asked a quick and pragmat-

ic question and has responded with a quick and pragmatic answer. How do you eliminate poverty? By giving people more money. . . . How do you improve incomes in agriculture? By supporting the price of grains. These questions have been given quick and explicit answers but those providing answers have not taken time to learn of possible side effects the answers might bring" (p. 15). The same is true in other disciplines. Frequently, scientists are not aware or ignore the limits to their knowledge. As noted earlier, all knowledge systems tend to be circular and closed and we tend to ignore other viewpoints. While space limitations prevent a discussion of the topic, it should be mentioned that the information we create may be more useful to one group than to another and can possibly give advantages to some at the expense of others. When we assume that knowledge is adaptive, we should always consider to whom it is adaptive.

Knowledge produced through scientific inquiry has another limitation when used in program development. Our descriptions and explanations are based upon a narrow range of information, and in generalizing to other circumstances, we should always mention that our statements hold *ceteris paribus*. When we deal with responses to known phenomena or similar conditions, we have some idea of the unknown variables implicit in *ceteris paribus*. On the other hand, when we are asked what the impact of some program will be that has never been tried, we have little information on which to base a prediction. Science deserts us at this point as does every other knowledge system. Most of us have not been trained as program planners; rather we were trained as scientists, and our knowledge of the operations of programs may be limited. It is wise at times to say that we do not know.

Where does all of this leave us? We must accept the limitations of the scientific approach to the study of human behavior and attempt to make policy makers, planners, etc., aware of these limitations. We should remain mindful of the role we have had in the past in the creation of social reality and in this light accept the responsibility for the consequences of our statements. Given the limitations of science, I support less centralized planning and permit local people to keep their resources at home, set their own priorities, and assume responsibility for their lives in as far as possible. Schumacher notes that the administrators in any large organization are in a difficult position. They carry the responsibility for everything that happens without having the information nor the time available to make adequate decisions. On the other hand, we live in a complex and interrelated world, and some central planning is necessary. An important task for the future is to determine the levels at which programs can be most effectively carried out and the information that will be required to assist in the process.

Despite the limitations inherent in the use of scientific methods in social inquiry, I believe that it remains the single best way to find out what is going on in the world. We must be very careful to determine what kinds of questions can be answered and what kinds cannot be answered through the use of scientific procedures. There are areas in which we can work with some effectiveness. First, we can evaluate programs and study the creation of social reality by policy makers, planners, etc. Do programs really produce the consequences they were intended to produce? What are the unintended side effects of programs? Who benefits and who is disadvantaged by policy decisions? We have skills that can be put to use in answering these and similar questions at local, regional, and national levels. We may never be able to answer the question of what will work, but we can determine if things are not working as intended. Second, social scientists can monitor other social processes that may not be directly related to policy decisions but that may pose a threat to one or more segments of the society. Environmental degradation, social costs of technology, inequality of opportunity, health care, etc.—the list is endless and these things require constant scrutiny. John W. Bennett once suggested to me that the social sciences would be well served if more of us behaved as investigative reporters. The monitoring process I have suggested is related to such an investigative task.

In order to evaluate programs and monitor social processes, we must work toward more inclusive paradigms or approaches such as the one proposed by Simpkins based on the concept of scale. A great deal of effort needs to be directed toward the development of a more unified theory of human behavior in which the diverse aspects of behavior studied by the various disciplines can be organized in a way that can be related to specific populations. It may be that such a unified approach is impossible. Certainly we are never going to be able to deal with human creativity and the diversity of be-

havior that it produces. Nonetheless, such a search will be useful if it only reminds us of our limitations from time to time. Such reminders are needed because, as noted earlier, all systems of knowledge tend toward circularity and closure.

Finally, even if we only evaluate programs and monitor social processes, we will continue to create social "facts" and be involved in the construction of social reality. When we embark upon any research endeavor, we must remain aware of the possible consequence of our actions. We make difficult decisions and there are no clear guidelines to follow. Becker suggests that we give some thought to the ethical and moral issues involved in social inquiry. We claim that we are not biased but, on closer inspection, the claim that there is an absence of bias is in fact a bias. I believe such a claim is an attempt to avoid the responsibility for our findings and statements. There are no value free or neutral paradigms. Furthermore, we cannot cling to our present approaches by simply claiming that they constitute the best viewpoint currently available. While they may offer us some security and provide a consistent framework for exploring the world, they are used at some cost to ourselves and to the people whose lives are changed because of the realities we have helped create. We must become involved in determining the costs of our descriptions and explanations. As we become more aware of our limitations and our role in the creation of social reality, I believe that moral and ethical questions will weigh more heavily upon us.

I have one last thought to share. Scientific disciplines are limited because they are systems of human knowledge. On the other hand, since we create them, scientific disciplines are unlimited; they can be so much more than what they are.

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Economics as Science and as Culture

L. M. Hartman

> Our meddling intellect misshapes the beauteous forms of things: We murder to dissect (Wordsworth, p. 57).

Two aspects of contemporary society motivate this paper. First, is the recognition of a growing awareness that our society is in a period of major social-cultural change, and second is the recognition of science as the major institutionalized and organized basis of knowledge within society (Bell). The implication is that science can either impede or facilitate the change. The proposition that economics is both science and culture recognizes that economics as a discipline embodies society's traditional sense of historical purpose and values but that it does so in the name of science. Culture is used conceptually to designate society's common sense of purpose and meaning (Bell). We conceive of a cultural tradition as the embodiment of society's historical, experiential knowledge (Cassirer). The paper develops around the proposition that experiential knowledge is the basis of human meaning and purpose and is prior to, and takes precedence over, scientific knowledge as a ground for action and choice (Cassirer).

The thrust of the paper is to clarify the distinction between cultural and scientific knowledge and, thus, the role of science, to give some historical background on how economics developed as both, and to develop some implications from this analysis regarding the future. This discussion necessitates considering science and the social sciences generally. Agricultural economics is an applied social science, and the implications will be expressed in terms of that discipline. One conclusion is that agricultural economics as now practiced is both bad science and uninformed culture.

L. M. Hartman is a professor of economics, Colorado State University.

Culture, Science and History

The basic proposition regarding the priority of experiential knowledge is derived from an understanding of human beings open to meaning and purpose and who act in accordance with the meanings and purposes they embrace. Culture develops, or is created, out of the historical experience of a society and, thus, it is appropriate to speak of a cultural tradition. Modern society was formed by several traditions extending to the beginning of historical time. The Greek and the Judeo-Christian traditions were integral to the formative process.

The proposition that knowledge growing out of experience takes precedence over scientific knowledge for action-choice situations requires elaboration on several points. The most crucial to the argument of the paper is the explicit recognition that the process of learning through experience results in knowledge and that this type of knowledge can be communicated and shared, i.e., can become public (Cassirer). This publicness is the basis of cultural tradition. The triumph of science has created the illusion that scientific knowledge is the only valid type of knowledge. Also, there is the recognition that action-choice situations are by their nature evaluative, involving qualitative aspects of different alternatives. Science by its distinctive form of knowledge precludes any decisive understanding of the quality dimension. Economic analysis of the choice process assumes the ends as given or assumes value priorities that originally came out of a community of shared values. Most importantly for the individual, knowledge developed through experience is decisive as formative of the consciousness and is developed only when responsibility is taken for the evaluative basis of choices. This understanding is implicit in our own western cultural tradition emphasizing freedom and autonomy.

To conceive of culture as knowledge is to view it as evolving and developing through

time, i.e., there is progressive movement towards greater understanding. Historical experience is the basis for exploring, formulating, and testing aspects of human potential. A tradition represents its cultural forms in terms of language, religion, art, literature, science, and technology as different aspects of experience and potential for creative expression (Cassirer). Prior to the modern period, a religious tradition dominated western society. The modern period has been one of transition from religion to science as a world view dominating the central institutional system. The disjunction occurring on the contemporary scene, in what some authors call the postmodern period, is the recognition by a significant minority that society has lost some qualitative dimensions to experience. The scientific community has failed to respond to the cultural conflict that has been generated. This failure to respond stems in large part, in terms of the charge of this paper, from the inadequacies of the world view of science. This world view permeates the approach to economics.

Science as a tradition is embedded in the scientific community. That community is the "carrier" of the tradition. It is institutionalized primarily within the university system with process for admittance into the community, viz., evidenced mastery of theory and methodology within the disciplines of the tradition. Transformation of that tradition must, therefore, evolve from that community in accord with common meanings associated with it.

We may pose the question—why is science crucial to the process of change and historical development? The answer—because embedded in the tradition of science are prescriptions concerning legitimate methodologies for growth of knowledge and selection of legitimate problems. The historical faith of science is in the ultimacy of a certain kind of natural order and the effectiveness of the scientific method to discover that order. Human progress is conceived in terms of the growth of knowledge and the power of that knowledge in the realization of human purpose. The original intent of science is to delve beyond appearances to the objective facts, to arrive at a new classification of phenomena, from that of common sense, where order would be discovered in consciously established relationships. As Hayek summarized, "the history of science is a progressive emancipation from our innate classification of external stimuli" (p. 20). The polar classification of perceptual understanding into the categories of subjective and objective that evolved out of that aim left the individual in a private world of his own. All qualitative dimensions of human experience were precluded from scientific understanding; thus, values and human purpose were left to the private world of the individual. Therein lies the problems of science as an inadequate cultural tradition. Experience within science has achieved a state of maturity to reassess its traditional grounds.

Economics as a Historical Discipline

According to Weber (1958, 1947), Tawney, and others, leadership in the establishment of early modern values, social purpose, and the institutional system emerged from Protestant Christianity, the dominant cultural tradition of the early modern period. The values of individualism, freedom and democracy, the pursuit of material goods as a religious calling, and the calling as the individual's place in society to contribute to overall good were a part of the tradition of the Protestant Christian community. The process of transformation taking place in the modern period was a process of secularizing that tradition, i.e., a transvaluation into the terminology and world view of philosophy and science.

Economics was originally conceived as a branch of moral philosophy. As such, the concepts of economic freedom, self-interest, utilitarianism, and the rationality of achieving economic ends were stated as a position primarily explicated in terms of the social good. As a position, that formulation was merely one view among others. It was consistent with the action orientation of the emerging middle class. Thus, economics was concerned with the establishment of the conceptual basis of a moral order in accord with the world view of science and with the emerging social purpose of the entrepreneurial class. Within the view of the historical process being considered in this paper, the openness to meaning and purpose became progressively shaped around the economic goal and the world view of science. The moral problem, as a problem of choice among possibilities and potentials, became a scientific one regarding the nature of man. Ethical options became scientific postulates. One end among other ends

became the end, and science as expressed in economics became a dogmatic formulation of the values and purposes of the established system. In terms of culture, the economic end and the rationality associated with that end became the dominating sense of meaning. In Polanyi's terminology, the activity of providing for material well-being became disembedded or separated off as a distinct sphere of activity. Economists presume too much if they think they shaped that world; they presume too little if they take no responsibility for the future.

Economics as Science and as Culture

As suggested above, science is the dominant orienting perspective in the western cultural tradition. Economics is the major discipline within science that formulated society's action rationality. In other terminology economics is an action paradigm or cultural paradigm, a conceptual model for problem and policy formation. In the concrete action setting of institutions and of interacting individuals, rationality or consciousness is shaped by self-interest and utilitarian ends as embodied within the system. The family and educational and religious institutions have become integrated into that social sense of purpose and meaning and have largely lost their own autonomy. The discipline of economics has incorporated this sense of meaning into the assumptions of its theory. The theory explains how self-interest oriented towards economic ends operates within the varied institutional settings of our society. The assumptions represent a moral order legitimized by the society within the constraints of a vestigial Christian morality. Up until the present, the economist would have done his job well if through his theoretical analysis he showed better ways to achieve utilitarian ends. However, when the economist asserts his assumptions as scientific postulates, he is saying, with all the authority of science, "these are the ends you should be pursuing, and this is the sense of rationality that you have, whether you know it or not." In that sense economics is bad science, and science is bad culture.

The problem with economics as a science is that it is impossible to test its assumptions within the system. Historical experience created the cultural-institutional system from which the economist abstracted his assumptions; therefore, testing back involves an incorrect circularity. Development economists have the opportunity to test these assumptions within the context of other cultures. An evident shift in the development literature recognizes the cultural differences but presumes that western society is still the ultimate model. No concerted effort reexamines the theory and its implication for our own society with the serious intent of questioning our own cultural integrity. The key cultural-institutional differences result from the fact that in nonwestern societies economic activity is not differentiated from other activities. They are integrated within family, community, and religious meanings so that there is no activity that is economic as such. The development economist has seen this as something to be overcome. The economist attempts to integrate family, community, and religious activities into economic rationality, presuming that self-interest, utilitarian rationality is the truth concerning man's nature.

As a cultural tradition science and economics are centered in the university, which educates, or rather trains, a major segment of society who become leaders in business and government. The university faculties are associated with business and government through research contracts and as consultants and policy advisors. With the loss of geographic community and diminishing influence of the Christian community as an effective moral force, government becomes the major moral force supported by the scientific community as interpreters and legitimizers. The upshot of this combination is the extension of government and centralized organizations into all spheres of national life, and all of this being facilitated by university scientists (Sorensen and Hartman). The agricultural economist, for example, promotes through his research and policy recommendations the extension of this "good" life into the last bastions of individualism in this country, the rural communities. The effects of this centralization of traditional functional prerogatives are alienation and loss of individual responsibility.

An Alternative Conception of Science and Economics

As pointed out above, one of the crucial aspects of the scientific world view was to dichotomize perceptual understanding into the

categories of subjectivity and objectivity. Subjectivity was relegated to the private world of the individual, whereas objectivity connoted reality. That conception has pervaded all of the social sciences and particularly economics. The economist takes values and preferences as given. The utilitarian view, as a part of the natural man conception of science, is based on the idea that man's sense of purpose is to achieve a subjective emotional system state where all desires have been satisfied. In that perspective the subjective is desire governed by the rational mind. Values in this view are values attached to aesthetic goods, not values in the traditional sense associated with moral responsibility and freedom. The view to be developed here is a radical departure from the dichotomy and polarity of subjective-objective classifications.

The scientist-economist is like a man in an illustration used by Kierkegaard, from which I will quote:

> The objective truth as such is by no means adequate to determine that whoever utters it is sane; on the contrary, it may even betray the fact that he is mad, although what he says may be entirely true, and especially objectively true. I shall here permit myself to tell a story, which without any sort of adaptation on my part comes directly from an asylum. A patient in such an institution seeks to escape, and actually succeeds in effecting his purpose by leaping out of a window, and prepares to start on the road to freedom, when the thought strikes him. . . . When you come to town you will be recognized, and you will at once be brought back here again; hence you need to prepare yourself fully to convince everyone by the objective truth of what you say, that all is in order as far as your sanity is concerned. As he walks along and thinks about this, he sees a ball lying on the ground, picks it up, and puts it in the tail pocket of his coat. Every step he takes the ball strikes him, politely speaking, on his hinder parts, and everytime it strikes him he says:"Bang, the earth is round." He comes to the city, and at once called on one of this friends; he wants to convince him that he is not crazy, and therefore walked back and forth, saying continually: "Bang, the earth is round!" (p. 174).

The proposition that experiential knowledge is central to human meaning and purpose is contrary to the notion that truth is only contained within the objectivity of western science. The plain fact of the matter is that objectivity is defined by a subjectively developed sense of meaning and that we become entrapped by our own creation. Science is a method for discovering order by a process of abstraction and theorizing. Theory is a created conceptual ordering of the phenomena in such a way that the theory can be tested back against the phenomena from which it was abstracted. Objectivity is the congruence of the theory with only certain aspects of the phenomena. With respect to the human sciences, the abstractive process reduces human beings to only selected aspects of total humanness. Each discipline is developed on the basis of some selected aspect, some partial view. It is only in action and experience that the total man is involved, and if we suppose that consciousness can become aware of itself, i.e., one can be self-conscious, then consciousness is the phenomenon of whole man. But a science of consciousness is contradictory because science is by its methodology reductive, and to reduce consciousness is to lose the integrating wholeness. The conclusion to be drawn is that scientific theories provide only partial knowledge that can be integrated only within experience.

It follows that the view of science as a source of knowledge for human meaning or consciousness is illusionary. Does that mean man is left only with the black box of an isolated subjective? I think not. The concept of experiential knowledge implies understanding and order and the possibility of testing value rationality in experience. Likewise, the conception of a social order based on freedom and democratic process, as a part of our own western tradition, implies a mutual agreement through communication and, also, the possibility of universal values that become known and understood through common experience.

The world view of science that propagates the notion that the only way to know is to know objectively through reductive theory, observation, and quantification is merely misleading under casual circumstances. That view is vicious when it is institutionalized within the cultural center of the establishment and, thus, controls action possibilities. It has the power to control through manipulation and to discourage the open communication processes that are essential for establishing a qualitative dimension to the social order. In other words, scientific objectivity leaves out value considerations. Values are only experienced as a part of the life process. "Yes," the economist replies, "we know that because it is part of our utilitarian conception of man." But the values we are talking about are not values associated with aesthetic goods, more correctly known as preferences, but values associated with the

creativity, freedom, and responsibility of the individual. The development of this sense of consciousness or rationality comes from the individual affirming himself as an individual with the capacity to make moral choices. Experience verifies that the responding (responsible) individual is also capable of affirming a caring relationship with others (Fromm).

No doubt most people, through their own experience, experience themselves as being utilitarian, rational, self-interested individuals. This brings me to the crux of the argument: experience is an interpretation, from a frame of reference, of feelings that develop out of an action situation. If the formative experience for the individual grows out of an action situation structured by rules and a cultural sense of meaning that affirm self-interest, utilitarian values, the individual will interpret his own feelings on that basis and that sense of meaning will become his sense of self-consciousness. This is the side of economics as culture; it assumes what is culturally and institutionally defined at the action level. Contemporary society has reached this impasse. Structurally we have lost the experiential setting of community where the values of caring might be experienced and affirmed spontaneously, and culturally society is dominated by a scientific, objective sense of meaning that can affirm only self-interest, utilitarian values. Cultural diversity allows those on the periphery of the mainstream to experience the potential within themselves to determine their own sense of meaning, i.e., to experience the potentials of positive freedom.

Our experience in community development work, within our own community of family and friends and in communication with others, provides empirical, qualitative data substantiating the view that human beings have the potential for developing a sense of moral responsibility in caring, trusting interactive relationships under appropriate conditions. This is the decisive test that utilitarian, self-interest rationality is not an innate sense of consciousness. That experience indicates a different kind of social order emerging than that of competitive self-interest regulated by a legal order, which economics and public choice theory formulate. I see the need for the integration of both types of order. An illustration from a student paper may suggest some aspects of that integration. The student had worked in a local restaurant and had developed a friendship with the owner-manager, who shared with the student his sense of intentionality in terms of managing his business. His intentionality was based on a genuine caring concern for others. He saw serving food in an appropriate atmosphere to be an opportunity to express his own sense of value. His help were hired on the basis of their sharing those values and, according to the student's account, this man ran a flourishing business. The student recounted in his paper his own sense of experience, e.g., work was no burden, tips were generous, etc., when he was feeling a genuine sense of responding to the patrons. The example may seem trivial. It is not meant to be. It is presented with all the seriousness of the position being developed.

One straightforward conclusion emerges from both the experience with community development work and from the theory, and it is that change only occurs sporadically, as in the above example, unless facilitated by informed and self-conscious leadership. The university community lives in a world of ideas and action oriented towards teaching, researching, and extending based on those ideas. My conclusion is that such activity is misdirected because of the nature of those ideas. The university must break out of its historically established world of ideas. Society generally is involved in activities directed by the institutions and traditions of the past. The consolidation of the university world in a more intimately empirical way with outside communities in a mutual search for a new sense of meaning is the dynamic we are proposing. For the agricultural economists, this means a different sense of problem formulation.

Implication for Agricultural Economics Research

What is discussed in this paper is not simply as a basis for a research program. It is not intended for that purpose. Its main purpose is to open a dialogue. The paper develops an argument for a value position from propositions that formulate a social theoretical framework that is defensible and testable. The thrust of the theoretical proposition challenges the basic assumption of economic theory. Within the conception of economics as culture, the assumptions are identified as evolving out of a historical consciousness shaped by a specific type of scientific world view and a socially determined goal of economic development,

more generally understood as a goal of mastery over nature. The contemporary sociocultural change is in the direction of other aspects of human potential for creative expressions. The implication for agricultural economics research is to develop the capacity to respond to that change process.

The change process has many facets. Within agriculture it may arise as a yearning for farming as a way of life, rather than just as a business and a part of the system. Within geographic communities, a reaction to the forces of outside control is developing. This reaction is in the form of a movement towards local control and more self-sufficiency. In the city and among the young we can observe a movement back to nature and natural processes, making technology a servant rather than a master. All of these facets have a common value, a search for a way of life by the individual that integrates economic activity as a creative part of a total life situation and allows more control and more opportunities for creative expression.

One paramount process in the search for new meaning and for the development of individual potential is the interactive communication process of sharing feelings and experience. Out of this process evolves a new sense of social order called community, as opposed to the order of an institutional system. This sense of community can exist among friends, within a family, within a university department, and within a geographic area. It can be dynamic and open and facilitative of individual freedom. The phenomenon of community may be understood as a form of creative expression, and creative expression may be understood as the process by which the individual achieves self-identity and develops an integrated self-consciousness. These statements about community can only be asserted; their meaning and truth can be experienced only by involvement and response. Agricultural economists could become involved and respond to that process, both within the university setting and in the setting of rural people. Out of that involvement would come a new sense of responsibility.

As long as the agricultural economist sees his purpose within the context of the scientific, technoeconomic cultural and institutional system, there is only one way to go, and that is to extend that system of meaning and purpose into all aspects of life. Current attempts to expand the economic theory rationale to public and family decision processes are an example. As a value orientation, that approach affirms the system as more important than the individual. Serving people is a different purpose than serving the system. To think that human beings can only act on the basis of self-interest and utilitarian ends is bad science. To think that that tradition is somehow sacred is to be uninformed.

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A "Scale" Approach to Community Development

O. Norman Simpkins

The literature on community development contains a plethora of definitions. For example, Biddle and Biddle list seventeen different definitions, some of which seem to contradict others. Community development is also frequently treated as virtually synonymous with such terms as modernization, urbanization, industrialization, etc. As to theories of development, each social science discipline has tended to go its own way with the result that there is no overall theory, only partial theories. Anthropologists tend to stress anthropological variables (Goodenough); economists stress economic variables (Rostow); political scientists, political variables (Apter); sociologists, sociological variables (Loomis); and psychologists focus on psychological variables (McClelland).

With all this variety, there does seem to be a common theme running through most of the current definitions of community development even though expressed in differing terminologies. This theme is that development implies a change in the community, region, or society toward betterment of the lives of the inhabitants of the community, region, or society. This change for the better is sometimes seen as a process and sometimes as a goal or end achievement. Also, the contexts in which most definitions are used focus on planned development or change, though they do not deny the possibility of unplanned development. What is needed is a definition of development that avoids as many of these limitations as possible. The following definition, I suggest, does this: community development is that process whereby a community, region, or society increases its scale.

Definition of Scale

The concept of scale has been in economics from the very beginning of its emergence as a scientific discipline. Economists usually limit its use to single organizations when they refer to economies and diseconomies of scale. The concept of scale used here follows the usage of two South African anthropologists, Wilson and Wilson. In studying the changes occurring in the tribal societies of Central Africa as a result of the impact of western civilization, the Wilsons developed an operational theory of social change utilizing the concept of scale which they define as follows: "By the scale of a society we mean the number of people in relation and the intensity of those relations. . . . In comparing the scale of societies therefore, we compare the relative size of groups with relations of similar intensity" (p. 25). This is a refinement of the concept of scale used by Hobhouse under whom both the Wilsons studied. Hobhouse, in turn, apparently based his usage of scale on the economic concept. Sorokin also developed similar views but did not use the term scale.

As the number of people in a community or society increases and the intensity of interactions with each other increases, their scale increases. As scale increases the rate of change or development increases. In other words, two communities having the same population size are equal in scale. However, if the intensity of interaction in one community is greater than the intensity in the other community, the community having the greater intensity of interaction is the larger in scale. The Wilsons assume that the intensity of relations, i.e., the total degree of dependence, is the same in all societies but that it may be more or less spread out.

The difficulty with the above conception is that the term intensity is extremely difficult to define and measure satisfactorily. The Wilsons get around this problem by developing and utilizing a number of behavioral indices for measuring intensity. These are (*a*) economic cooperation both within and without the group; (*b*) communication of fact in speech and writing both within and without the group;

O. Norman Simpkins is the chairman of the department of anthropology and sociology, Marshall University.

(*c*) emotional (i.e., artistic) expression communicated within and without the group; (*d*) the value set on contemporary cooperation and continuity within and without the group; (*e*) the relative degree of unity and continuity asserted within and without the group; (*f*) the degree in which a sense of unity and continuity is expressed within the group; and (*g*) the degree of social pressure exerted on and by outsiders.

From these seven behavioral indices the Wilsons go on to develop eight correlates of scale by which increases and decreases in scale can be measured empirically. From analysis of their discussion of the social changes occurring in Central Africa and from conversations with Monica Wilson, I have identified eight more. These sixteen correlates fall into four broad categories of human behavior as follows: those relating to the ecological level or to control over the material environment; those relating to the sociological level or to autonomy among people; those relating to the cultural level or to variety of ideas, symbols, values, etc.; and those relating to the psychological level or to autonomy of self (see table 1).

Correlates of Scale

The four sectors or levels of table 1 are arranged so that the more concrete correlates are at the bottom of the diagram, the more abstract ones are at the top, the ones pertaining to the individual are on the left, and the ones pertaining to groups are on the right of the diagram. The Roman numeral identifying each sector is in the order of increasing difficulty of measurement. Those correlates designated by the same capital letter relate to the sector in which they are placed as well as to the other sectors as follows: A's relate to sector I, B's relate to sector II, C's relate to sector III, and D's relate to sector IV.

Explanation of each of the sectors and correlates follows. Ecological level (control over the material environment), level I: As communities or societies increase in scale, they increase their control over the material environment and vice versa. Measures of this control are (A) energy development: Throughout history as communities have discovered or developed new forms of energy, they have been able to improve their level of living whether it has been the domestication of large animals, discovery of wind power, steam power, electricity, or nuclear energy. Thus, they are able to do more with less human energy and also increase their probabilities of survival and growth. One of the first applications of new forms of energy is usually toward the transportation system that is partially effective in increasing scale. (B) Occupational specialization: The larger the number of occupational specializations in a community or available to it, the greater are the chances that problems encountered will be solved, thus enhancing the probability of increase in scale and of survival. (C) Technological development: The development or discovery of new techniques enables a community or society to in-

Table 1. Expanded Correlates of Scale

III. Cultural Level (Variety of Ideas, Symbols, Values, Etc.)
- A. Communication of facts
- B. Identification with others, both past, present, and future
- C. Intellectual variety
- D. Artistic variety

IV. Psychological Level (Autonomy of Self)
- A. Technical skills
- B. Interpersonal competence (empathy)
- C. Symbolizing ability (intelligence)
- D. Self-awareness (self-concept, self-identity)

II. Sociological Level (Autonomy Among People)
- A. Economic cooperation (trade)
- B. Social mobility
- C. Impersonality
- D. Social pressure (influence)

I. Ecological Level (Control Over the Material Environment)
- A. Energy development
- B. Occupational specialization
- C. Technological development
- D. Scientific methodology (nonmagicality)

crease its scale and thus increase its survival probabilities. (D) Scientific methodology (nonmagicality): As a community or society utilizes scientific methodology rather than magical techniques, its control over its material environment increases and the use of magic tends to decline.

Sociological level (autonomy among people), level II: The correlates relating to this sector have to do with interpersonal interactions of the population of a community or society. As the following correlates increase, individuals and groups have more choices available, thus autonomy and scale increase. (A) Economic cooperation (trade): Economic cooperation enables a community or society to utilize resources not available locally, thus increasing scale. Along with trade goes communication of ideas, values, etc. (B) Social mobility: Increase in social mobility increases scale and increases freedom of choice. A community or society that limits mobility of its members limits its scale since the talents of those so limited are less available to the entire society. (C) Impersonality: As the ability of the members of a society to operate in impersonal situations, i.e., in terms of roles, increases, the scale of the society increases, thus increasing autonomy of individuals. Individuals able to operate only in personal situations are limited in scale, and this in turn limits the scale of the community or society. (D) Social pressure (influence): As the extent of social pressure or influence people exert on each other increases, the scale of the community or society increases. Social pressure makes organizations possible for otherwise concerted action would not exist.

Cultural level (variety of ideas, symbols, values, concepts, etc.), level III: The key to the correlates of this sector is variety. The greater the variety available in a community or society, the greater the possibility that use will be made of them and hence the greater the scale. (A) Communication of facts: The greater the communication of facts, i.e., reliable information, the larger the scale of the community, since more people have available more information on which to base decisions and acts. (B) Identification with others, both past, present, and future: The wider the range of identification with others as being essentially like oneself in one or more essential characteristics, the more communication and interaction is facilitated and hence the larger the scale of the society or community. (C) Intellectual variety: The greater the number of different views, frame of reference, *weltanschauungs,* etc., in existence in a community or society, the greater the choice in the development of a relevant world view and hence the larger the scale. (D) Artistic variety: The greater the variety of artistic expression in a society, the wider the range of choices in the outward expression of inward emotions and feelings and the larger the scale.

Psychological level (autonomy of self), level IV: The correlates in this sector refer to those areas of individual behavior and understanding that lead to increase in scale as they increase. (A) Technical skills: The more technical skills individuals possess, the larger their scale and the more resources the community has available. (B) Interpersonal competence (empathy): The key characteristic of interpersonal competence or empathy is the ability to see and understand situations from the other person's point of view. (C) Symbolizing ability (intelligence): This correlates refers to the ability to create symbolic abstractions as well as use them. (D) Self-awareness (self-concept, self-identity): Awareness of one's self as to who one is and what one's relation to others are is the key to the development of a self-actualizing or autonomous personality. The same applies to a group or community.

The set of sixteen correlates of scale briefly described above constitute an integrated system of concepts relating to all areas of human behavior. (Because of space limitations, illustrative examples of each correlate have been omitted.) Each correlate is so defined as to be positively correlated with each other and with the scale of the individual, community, or society. As the value of one correlate increases or decreases, the values of the other correlates tend to vary accordingly, not in a mechanical fashion but in an interdependent one.

In any real life community or society the values of the correlates will not be even at any one time. Some elements of the community or society will be larger in scale than others. This condition of unevenness of scale results in disequilibrium, opposition, strain, and conflict (Wilson and Wilson). Differences of scale will exist among different communities. Discrepancies of scale may also occur in which one might find a large-scale individual in a small-scale community or vice versa.

Within a given society the increase in scale of one community may cause a decrease in scale of other communities as a result of

changes in terminology, economic conditions, decisions of authorities, or other events. In the same way increases in scale of the larger society as a consequence of changes in one or more of the correlates of scale may result in a decrease in scale or even elimination of one or more local communities. For example, the dieselization of the railroads after World War II, which increased the scale of the United States, resulted in the decrease in scale of some railroad towns (Cottrell).

Use of the Correlates in Guiding Community Development

The concept of scale presented here does not provide a how-to-do-it manual for the community developer or change agent. It does not provide a community with information about what to do in any direct sense. It does provide a kind of paradigm for evaluating the probable consequences, many of which are latent rather than manifest, of whatever may be proposed whether the proposal be made by the developer, authorities, or the citizens themselves. Most current attempts at development tend to focus on the introduction of some new technology on the assumption that other desirable changes will in time ensue. The concept of scale enables developers to know more about where to look for those consequences and whether the results are likely to be positive or negative as far as development is concerned.

It opens the way for other than technological changes to be considered in a more balanced fashion. Use of this paradigm will help to prevent social or cultural blindspots from handicapping planned projects. It also makes it possible to have a more adequate basis for making decisions about trade-offs since no community ever has enough capital and resources to do everything it wants to do at any one time. It also enables a community to make a better estimate of the cost it may have to pay for certain developments.

This concept of scale enables developers to think on different levels of abstraction, avoid oversimplification, and avoid two-valued thinking. It helps in looking at a development program in holistic terms rather than only in analytical modes of thought. It is a continual reminder that "everything is connected to everything else."

Since community development has from its beginning stressed mass education of citizens as a major part of the development process and many practitioners of community development still do, the concept of scale as presented here fits well into this approach. It forms a workable framework for the development of educational curricula and programs. It is not very difficult to communicate the basic idea of scale to the members of the community, which then results in an additional impetus to the developmental process once a program has begun. All in all it provides a set of checks and balances that helps to avoid the hazards of a community "putting all its eggs in one basket."

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Discussion

Paul W. Barkley

The three papers dealing with community development are the result of several years of affiliation among the scholars who presented them. I have been on the fringes of this affiliation, and this group of papers does not represent the best work of the group. Perhaps the group's best work comes only in intimate communication and does not transfer easily to the printed page.

The group is concerned with *community* in its grandest sense. Sometimes this concern focuses on development, sometimes on interpersonal relations, and sometimes on more pedestrian themes such as individual community facilities. Unfortunately, in this airing, only the Simpkins paper is involved with community. Hartman and Moles became mired in considerations of science and its relationship to culture and to truth. While these topics are of vital concern, they serve only to detract from the stated purpose of this session.

The Hartman paper is a misplaced *tour de force*, but it is not without precedent in the subdiscipline of agricultural economics. From time to time a number of agricultural economists have been frustrated by what they have been doing and how they have been construing reality. They bemoan irrelevance and admonish their followers to be more careful in selecting problems, stating assumptions, manipulating data, and inferring from small samples to large populations. These admonitions are healthy and sometimes lead to magnificent pieces of work. The best examples include Salter, Kelso, and Castle. These works make no pretense about focus; they are directed at the entire profession. The Hartman paper, too, is directed at the profession but for some reason harbors a minor pretension about community development. In my opinion, the pretension (or the foil) could as well have been dairy marketing or land tenure.

Hartman is stating some serious problems. Economists, especially applied economists, are indeed wont to confuse assumptions with postulates; they do live in a world guided by incomplete specification; they do have limited and self-serving objectives; and their thinking is dominated by objectivity while subjectivity is relegated to philosophers, theologians, politicians, and the very young. These points are well taken. The problem of culture, however, is not. There may be a western culture existing in opposition to an eastern culture or a third world culture. The western culture is large and diverse. It has so many dimensions that it cannot become an adequate framework for a discussion of the frailties and limitations of science or scientists. A discussion of a subculture centered in the academy would have been preferable.

It is no doubt true that the academy has become very narrow in its goal orientation. Those of us on the inside have responded to pressure to secure outside funding—funding that is often tied to very selective objectives and leads to research results that can be turned into large private gain. The opportunity to be creative is still present, but it carries high risks when compared with the bread and butter research that is open to nearly all of us. We have created a system that can be very profitable even while it pursues a relatively honest grade of science. It is to be condemned because its scientific endeavors are not as intense nor as innovative as they might be.

But what has this to do with community development? Are practitioners of development any more liable to commit these sins than those pursuing other branches of agricultural economics? I think not. If anything, they are less able to because their clienteles do not usually have the money to buy favor nor to purchase narrow research. Moreover, most (if not all) community problems are public problems, and solutions to them come in the form of nonappropriable public goods. Researchers in this arena may be involved in bad science, but it stems from their lack of knowledge of science or from their lack of inventiveness. It does not come from the frailties of the system or the selfish drive for personal gain.

I turn now to Hartman's comments on

Paul W. Barkley is a professor of agricultural economics at Washington State University.

community. One must differentiate between a community as a place and a community as a sense of involvement or human interaction. Hartman discusses the latter, although one gets the impression that a place is implied and that place is, moreover, a rural place such as one might find in the Plains, in the South, or in the West. To develop this community, one must improve interpersonal relationships and develop a sense of intimacy and reciprocal responsibility.

No one will doubt this. The question is: what can economists do to improve the capacity of those in a community to adopt a more selfless attitude toward their fellow men? This is not an easy thing to do because the assumption of acquisitiveness says we must grow to succeed; the assumption of empathy says we need not grow to succeed. Veblen, Galbraith, and Boulding have ventured into this land. Veblen wonders how tastes and values were formed, but he does not make these issues a part of the conceptual framework he uses to describe man. Galbraith takes up the cudgel but cannot do much more than describe the difference between man as a private person and man as a public person. Boulding comes the closest. He states continually that benevolence is a consumer good and that one can increase his own level of satisfaction by helping others. Boulding stops here and becomes a muse for later-generation economists. How does one give empirical content to these ideas? Here may be a starting place for economists to exercise their particular skill and to draw on their traditional concepts and tools.

Action programs are quite another thing. I am not confident that economists or anyone else from the academies will be more than modestly successful in making people adopt the quiet and personal dispositions of compassionate interdependence, mutual respect, and harmony. I doubt that those involved in domestic community development work can afford the time or financial resources needed to bring even one community along the road to development in Hartman's terms. It is a good idea, but the cards are stacked against it.

Moles takes a more positive stance toward science than Hartman does but is still critical of the practice of science in a monastic setting. Moles' science is evolutionary. It is based on perception and refutation. It requires investigators to abstract and simplify in order to find common threads that connect realities. The realities are negotiated when partial knowledge requires acceptance of one view rather than several. The world was flat to the denizen of medieval Europe because no other notion was necessary regarding the shape of the earth.

Moles has an interesting construct in his closed circle of knowledge. The job of science is to expand the dimensions of the circle, but the circle must remain intact. It it is broken, a whole series of new truths and perceptions may be needed to reestablish its integrity. The discovery of the Van Allen belt required the reinvestigation of aspects of the solar system.

Although Moles says nothing about communities, there is a lesson to be learned from the conjunction of his work with Hartman's. Hartman tries to maintain a circle of relationships within his community; Moles needs a circle of knowledge in scientific enterprises. When the Moles circle is broken, the whole system shudders and threatens to collapse. One suspects that when Hartman's community is threatened—either by a new member or a new idea—it comes close to collapse too. Moles suggests that knowledge is not stable. I believe community to be unstable also.

The Moles paper has one other remarkable attribute. Toward its end, it asks about the appropriate size of administrative units. At what size can administrators exert "effective" control? Herein lies one of the most important problems in community development: who should be in charge? A vast literature has developed to define the geographic limits of American federalism. This literature comes from a notable group of scholars inside and outside of agricultural economics. Most assume rationality and individual freedom of choice. Their work breaks down in transferring from individuals to groups. Herein lies Moles' problem. He wants a system that is responsive yet able to make use of technological change and take advantage of economies of scale. The combination is frustrating and leads to tremendous duplication, waste, and an overlapping of jurisdictional units. Moles correctly implies that this is part of the reality we create.

The Simpkins paper is directed at this audience, and it relates to the stated theme of this session. Simpkins is an anthropologist, so he has a considerable claim on the topic of community and communities. Unfortunately, anthropologists and economists use the language in slightly different ways. Simpkins picks up on an idea closely akin to the economists' idea

of scale. Apparently, it is familiar to most anthropologists, but the usage is somewhat different from the economists' concept of scale.

For Simpkins, there is a connection between sixteen attributes of a community and that community's scale. Moreover, these attributes have internal and external dimensions. Scale increases when internal specialization and trade takes place. Scale also increases when specialization and trade vis-à-vis some external area increases. One is inclined to think that the attributes have very different weights and that some may be complementary while others are supplementary or even competitive. Simpkins notes that attributes have differential degrees of difficulty associated with their measurements.

The Simpkins scheme is disappointing in that it implies that the scale of a community increases whenever there is an increase in any of his sixteen variables. All scale relationships are, then, in stage I or stage II of a production function. I am not this hopeful. Communities, even very small ones, are filled with distrust, spite, envy, greed, lust, and the lesser forms of evil—rivalry, jealousy, and indignation. Any of these can put the development of the community into stage III. Where do these fit in the Simpkins model? Moreover, how are we to make the model operational, and what will it tell us once it is? Will the model be a guide to local, state, or federal policy? Simpkins is on to something, but I need specifications, and I need clear glass rather than rose-shaded lenses when I begin to work with his model.

In sum, this session on community development has provided a forum at which several first-rate scholars could vent their collective wrath on the establishment and on the conduct of science. The topics need to be addressed. But the topic of community development needs to be addressed too. There are thousands of communities in the United States. Some are in isolated, rural areas, and some exist in the middle of more metropolitan areas. These communities suffer an unbelievable number of social and economic maladies. To date, neither the New Frontier nor the War on Poverty nor the Great Society has been able to help to a significant degree. The scientific community has some responsibility for the communities' present condition, and it should take some pains to alleviate the unwanted side effects of the progress it has created. This is not best done by berating the system. It is best done by doing good science and asking publicly employed persons to become risk takers in purveying the new-found knowledge. We need someone to learn about the relationship between capital fixtures and people. We need someone to learn about coping with scarcity, choice, and change. We also need someone to inquire into commonalities and differences; convergence and divergence within, between, and among communities.

Certainly we need Hartman to keep us honest, and we need Moles to give us perspective on the appropriate role of science. We need Simpkins to provide new twists to old researches. Most of all we should hope that this same group will continue to deliberate their problems and eventually provide us with a more pragmatic discussion of a very puzzling set of problems.

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Irrigated Agriculture under Stress
(Charles V. Moore, Economic Research Service, USDA, University of California, Davis, Chairperson)

Pressures Created by a Severe Drought on Water Institutions

Ronald B. Robie

California has a complex and diverse water resources management system. Within the state there are about 195 major surface reservoirs with a capacity of 48,100 cubic hectometers (39 million acre-feet). The state is underlain by an extensive aquifer system that has a usable ground water storage capacity of 176,400 cubic hectometers (143 million acre-feet). Ground water pumpage has averaged over the recent past about 18,500 cubic hectometers (15 million acre-feet) per year, or about 40% of the state's total applied water use.

A myriad of water districts and agencies have evolved to tap these vast water resources. In addition to the reservoirs and conveyance facilities of the State Water Project and Federal Central Valley Project, California has hundreds of regional and local water storage and distribution systems. Among them, California's water purveyors provide the water for the state's agricultural and municipal and industrial needs. In 1975, the total statewide agricultural and municipal and industrial applied water usage was approximately 47,600 cubic hectometers (38.6 million acre-feet). About 85% of this figure represents applied agricultural water. Of this agricultural water, approximately 62% was supplied by local agencies and individuals, 34% by federal projects, and 4% by the State Water Project.

Most of the major waterworks systems now operating in California have come on line since California's last real drought during the 1928–34 period. Because that seven-year dry period was the worst on record, it served as a base against which the safe yields of projects were established. The contribution made by California's water systems has been great during the drought, and the ability to cope has been quite amazing considering the growth of population and irrigated acreage since the drought that occurred 40 years ago. During 1940–77 California's population jumped from 6.9 million to 21.8 million—a three-fold increase. In that same time period (up to the drought), irrigated agricultural acreage more than doubled—from 4.5 million to 9.3 million.

Why is California enduring a drought? There is simply less water running off this year than at any time in California's history. The record dry period has been surpassed. To illustrate the condition California is facing, table 1 shows the average annual runoff for the four major rivers in the Sacramento Basin for three different time periods. The 1975–76 water year (1 October 1975 through 30 September 1976) was the third driest in history. However, it was followed by the 1976–77 water year, which, when it ends on 30 September 1977, will have turned out to be the driest year on record. For planning purposes, the probability of such a dry year based on historical experience would be extremely low or, for all practical purposes, rated at zero.

Because of California's extensive system of state, federal, and local projects, the drought problems suffered during 1975–76, though serious, were fairly isolated. During the second drought year, however, the tentacles reached out to include the entire state in their grasp, affecting agriculture, industry, the economy, the environment, and the general public.

California had many water problems before this drought—quantity/quality interrelationships, lack of control of ground water, instream use conflicting with other water uses,

Ronald Robie is the director of the California Department of Water Resources, Sacramento.

Table 1. Average Annual Runoff, Four Major Rivers in the Sacramento Basin

Period (in Water Years)	Cubic Hectometers	Million Acre-Feet
50-year average (1921–70)	21,070	17.08
Historical dry period (1929–34)	12,063	9.78
Current dry period (1976–77)	8,017	6.5[a]

Note: The four rivers are the Upper Sacramento, Feather, Yuba, and American rivers.
[a] 1976: 8.2 million acre-feet; 1977: 4.7 million acre-feet (preliminary).

to name a few—and the drought exacerbated them. The complexity of drought problems and solutions has sometimes been hard for the public to grasp. There has been much public pressure for easy answers when, in fact, there are none. Water management and the operation of today's water supply and delivery systems is not an exact science, and there are shortcomings in both our knowledge and operating procedures. For example, the data base relied on for forecasting runoff from the mountains does not include years comparable with this one. We are without experience that could tell us what to expect under today's conditions. Extrapolations from past experiences have proved surprisingly useful, and model studies are of assistance, but they do not provide all of the answers.

In spite of the difficulties posed in water projects' operations due to information gaps, we are learning important things such as the way water use patterns change during a drought. Although traditional wisdom has dictated that drought periods are times when water users must take shortages, the demand for water is actually greater in a dry year. Farmers and urban residents tend to use water earlier in the year to make up for lower than normal soil moisture and because of higher spring temperatures. In 1977 more than 50,770 cubic hectometers (41 million acre-feet) would have been used for urban and agricultural uses compared with a normal year of 37 to 38 million acre-feet.

The California Department of Water Resources (DWR) and other agencies are undertaking programs to fill in some of the blanks in our data. One program of special interest is a data collection effort being undertaken by DWR economists. The objective is to define better the production functions of California agriculture, particularly as they relate to water. From this data, it should be possible to construct loss functions as related to water quality and quantity. The Department's economists have developed and utilized a statewide input-output (I-O) model to evaluate the economic impact of the drought. They are continuing to improve the model and to develop regional I-O models. The public demanded quick and comprehensive analyses of potential drought economic effects.

I do not mean to dwell on the information we have yet to learn. The drought has enabled us to gain practical knowledge about a number of drought management assumptions, strategies, and mechanisms. We have learned much about water conservation and about how people respond, how large reductions can be, how to enforce compliance, and how to establish goals. However, the concept of water conservation runs against the grain of many water utility managers, who generally see their roles as meeting needs, not reducing demands. Yet this is a very important part of good water management. Utility managers are now called upon to emphasize approaches that have not traditionally been considered as within the scope of the manager's role.

We are finding that in a drought urban residents conserve water voluntarily without mandatory rationing if they perceive a legitimate need. Where the situation is critical, mandatory rationing with fines for excessive use may be necessary to impress on the public the seriousness of the situation. Experience in the present drought shows that, with an urgent and perceived need, greater than 50% cutbacks in municipal use can be achieved. Industries can cut back, but not nearly as much as urban residents. Some industries could save more than they do but have not in order to hedge against more stringent regulations next year. At a recent drought conference, several industries indicated they could reduce water use but did not in order to retain some cushion in the event of future governmental restrictions. The California Department of Water Resources has contracted a survey of 6,000 specialized firms within California to determine their reactions to various water shortages. Preliminary results indicate that, with a

25% water reduction, only 20% of the firms would decrease production and that none would shut down, quit, or relocate.

Farmers also can get by on less water but again not to the same degree as urban users. Essentially, the same acreage is being irrigated in California this year with 15% less water. When adequate water is not available, farmers tend to put off salt leaching, use better water control, maintain perennial crops, and switch to lower water use crops. In other words, in times of shortage, agriculture can take deficiencies and still maintain reasonable production levels. The question is for how long?

There are many areas where increased on-farm efficiency can result in energy savings, reduction in water quality degradation, and increased flexibility in overall water management. The Department is exploring incentives for additional agricultural water conservation actions by farmers, urging long-range programs that will lead to more efficient use of irrigation water for agricultural, industrial, and domestic purposes, for example, drip and sprinkler irrigation where possible and increased promotion of irrigation management services provided by both the governmental and private sectors. The Department also believes that there should be additional federal funding to the Agricultural Stabilization and Conservation Services' Agricultural Conservation Program for cost sharing to cover purchase of irrigation equipment and other irrigation-related costs where this will result in water savings.

As indicated, urban water conservation has been very successful, so successful in fact that a national controversy was triggered when one San Francisco Bay Area official began urging that people stop saving water because water conservation was surpassing expectation, lessening revenues to the water utilities and prompting a traditional institutional response. The incident gained wide media attention and caused widespread public reaction.

State officials pointed out that, rather than cutting back on conservation measures, which would in effect be using more of next year's water reserve in an effort to balance utility finances, it makes more sense to explore alternatives, such as (*a*) adjusting rates in order to ensure necessary operating revenues during the drought but returning to existing levels once normal water supplies again become available; (*b*) using lifeline rates to work out inequities to the poor, the elderly, or others who are disadvantaged; and (*c*) using rates that heavily penalize excessive or unnecessary use of water during the drought emergency.

Another water management mechanism that has proven successful in spite of normal institutional constraints is the concept of water exchange. The Department of Water Resources has encouraged and developed water exchange contracts to voluntarily reallocate water from areas with sufficient supplies to water short areas. To date, the Department's efforts have been met with a fine spirit of cooperation. Exchange agreements have been accomplished to transfer more than 430 cubic hectometers of water (355,000 acre-feet) to areas of need. (In allocating the exchange water, the state included a requirement that no exchange water be allocated to lands not irrigated last year.) Prior to the drought, who would have been so bold as to suggest that water from the State Water Project that had been allocated and contractually committed for delivery to southern California would be voluntarily reallocated and by a rather complex physical and legal process delivered to a northern California county, which was not a State Water Project contractor nor within its service area? Nevertheless, it has happened.

Not all of the exchange water has gone to municipalities. In fact, the lion's share, 370 cubic hectometers (approximately 300,000 acre-feet), has been reallocated from the highly industrialized and urbanized area of Los Angeles to the irrigated agriculture areas of the lower San Joaquin Valley. Some economists might argue that this seems inconsistent with economic theory, particularly in times of water shortage. However, it is sound if there is sufficient slack in the water demand schedule such that little is sacrificed by urban users in the way of productivity, profit, or even convenience compared with the very substantial gains (or the losses averted) by the irrigation farmers in the San Joaquin Valley.

Perhaps most surprising is the evidence of such high payment capacity as demonstrated by the willingness of agriculture to pay the very high costs of exchange water.[1] However, this

[1] Take, for example, the 1977 canal-side costs of one State Water Project contractor. If the agency could have been delivered all the water requested, their average cost would have been between $10 to $15 per acre-foot (entitlement water plus surplus water). However, this year they paid about $43 per acre-foot, an increase of about $30 per acre-foot or $100 per irrigated acre. Several districts in the service area have asked the state to spread their 1977 charges over a period of several years, and the DWR is considering this request.

willingness to pay is only for the short run and is the farmer's response to minimize losses or to possibly avoid bankruptcy in a drought year and would not represent a long-term ability to pay for the water.

About two years ago, the California Department of Water Resources started a study to determine the feasibility of purchasing agricultural water entitlements applied to high-water-using crops and/or surplus crops for redistribution to high priority uses. Similarly, under emergency drought legislation enacted this year (PL 95-18), the U.S. Congress authorized the U.S. Bureau of Reclamation to act as a nonprofit broker in water transactions. However, this was not successful in California. Open bidding and brokerage of water supplies carries some basic institutional problems that have understandably made sellers wary and the legal implications have not been fully explored. The State Water Resources Control Board authorized hearings for water right transfers under its jurisdiction, but many water rights are not subject to Board control (riparian, pre-1914 appropriative, and ground water). Exchanges of these waters are at the peril of the parties and subject to legal challenge. The State Water Project's successful transfer was facilitated by the existing institutional mechanism—State Water Project contracts for the most part.

Another problem is that we have limited physical capacity to transfer water to areas of shortage. While there are interconnections within regions, connections between regions are few. We do not have a water grid comparable with the energy grid. (Most water exchanged went to state water contractors who were already interconnected.)

Some drought problems are the result of psychological factors. Although most water projects were planned to serve through both wet and dry years (with shortages during dry years), the planners failed to foresee the psychological effect of the economic and other adverse impacts of taking shortages. The state has had forty years without serious drought conditions. People forget. A "rose-colored glasses syndrome" sets in, and people refuse to believe that a drought exists and that it may continue. Although by early 1976 it was clear that precipitation in the 1975–76 water year was going to be low, most areas continued using water at near normal levels. There are few institutional mechanisms to control unwise use. The State Water Project did curtail some deliveries with an eye on the dry year ahead, but much criticism was received for doing so, particularly from agricultural customers in the San Joaquin Valley.

As the drought progressed into 1977, the situation was particularly difficult for state water contractors in the San Joaquin Valley because the state's water contracts call for a dry year reduction to agricultural contractors of 50% before municipal and industrial contractors take any cutbacks. Then, cutbacks proceed equally. For example, if municipal and industrial users are cut back 10%, agricultural contractors are cut back a total of 60%. When these cutbacks occurred in 1977, the impact was further aggravated by the fact that water users in the State Water Project service area had become accustomed to, and relied upon, the relatively inexpensive surplus water deliveries. They had planned on the use of surplus water during dry periods to help pay off initial investments that had been made in the previous ten years developing land for agricultural use.

In 1977, San Joaquin Valley contractors increased their reliance on wells, as did most other Valley water users. More than 3,000 new wells were drilled, and the overdraft is about 4,317 cubic hectometers (3.5 million acre-feet), as compared with 1,850 cubic hectometers (1.5 million acre-feet) in a normal year. There have been severe financial problems for some of the contractors because of the costs of obtaining temporary additional supplies from ground water on top of paying for the fixed costs of surface supply facilities.[2]

As an example of the impact of the drought on State Water Project agricultural contractors in the San Joaquin Valley, considering 1975 conditions as 100%, districts within one service area that rely solely on state water irrigated 95% of the acreage with 86% of the water in 1976. Similarly, in 1977 the values are 79% of the acreage with 63% of the water. This indicates an improvement in application efficiency in both years, but more significant is the probable stressing of some crops with consequent yield reductions in 1977.

Districts having additional water available are able to maintain nearly normal operations. Considering the total acreage irrigated by all

[2] In one district alone, for example, at least $1.4 million has been spent in order to increase ground water yield, in addition to pumping and other operating costs.

available water in the districts having additional supplies, their acreage totaled 100% in 1975, 101% in 1976, and 89% in 1977.

Irrigated agriculture, as any water-dependent industry, is reluctant to takes shortages. On the whole, California farmers are willing to take all the water that they can obtain now, even with the knowledge that potentially there could be no supplies available in the next year. The California farmer is a traditional risk taker, and many seem willing to maximize revenues in 1977 at a risk of having losses equal to fixed costs in 1978. We must develop more precise and predictable mechanisms for operating water projects and imposing shortage formulas, taking into consideration the need to carry over supplies to the next year.

On a long-term basis, we must reexamine the shortage formulas in water service contracts. It has always been assumed that municipalities could not take shortages and that agriculture could. However, the drought has shown that both can take shortages. In fact, municipalities have a greater potential for conservation.

Several other institutional problems associated with droughts are, briefly, (*a*) drought as a disaster: Most government financial assistance programs are geared to disasters such as floods or earthquakes, where there is one quick blast of destruction. Compensation, when it comes, arrives well after the fact. Fortunately, there have been signs that the federal government is becoming more aware of the gradual and anticipatory nature of drought disasters. Two examples of this are the Farmers Home Administration's new regulations that make emergency drought loans available to farmers for "prospective losses" and legislation that, if enacted, will grant similar loan authority to the Small Business Administration. (*b*) Emergency powers: Just what powers are available to various levels of government in an emergency? Who has the power to declare when rationing is needed? At what levels should certain decisions be made?

(*c*) Effectiveness of existing state water rights and water quality laws: The drought has particularly underscored the problems with the ground water laws, which permit unlimited new wells and provide no administrative mechanisms whatever to deal with ground water pumping. This year, Governor Brown established a commission to review California water rights law and to consider any needed changes in the water rights system. (*d*) Long-range forecasting: Long-range weather forecasting is still at an experimental stage and is not yet sufficiently proven to be a basis for critical operating decisions. Studies by the DWR, however, show that some skill appears to exist in seasonal weather forecasting. Extensive additional research is needed to improve these techniques and to establish their accuracy. Reliable forecasting techniques would be the single most important improvement in drought operations.

Although we have learned a good deal during this drought, school is not yet out. Even if 1978 is not a dry year, the drought will not be over. What if next year is below normal? Prudence dictates that we be conservative in future plans and not assume that the drought is over. In updating the plan of operations for the State Water Project, the DWR is assuming that water conditions of 1976–77 will prevail through 1978. The Department also is developing contingency plans to help local communities deal with the drought in the event that the coming winter is again dry. These will involve tearing down institutional barriers. The months ahead will be critical ones.

I particularly hope that when the drought is over we do not forget the lessons we have learned. The drought has created problems for society as a whole, but it is these societal problems that offer a rare opportunity for the economist, the engineer, the lawyer, and others to identify and document strategic data and responses while the drought persists. Finally, it enables the development of new procedures for the future.

Defining Upper Limits to Groundwater Development in the Arid West

O. R. Burt, R. G. Cummings, and J. W. McFarland

As western states attempt to respond to national needs for increased production of fossil fuels, the scarcity of water in this area looms as a major potential impediment. This is particularly true in the Rocky Mountain region, wherein coal production is expected to increase by more than 500% (Federal Energy Administration). With few exceptions, surface water supplies in this area are totally developed. Currently, efforts by state and regional planners to deal with the resulting dilemma—pressing needs for rapid industrial development and water scarcity—involve one or both of the following: reallocation of water from agricultural to municipal/industrial uses, and/or development and exploitation of groundwater stocks (*Albuquerque Tribune* 1976b, c; Cummings and Gisser).

In considering the possibility of rapid groundwater development in the western states, one has ample cause for concern given this area's experiences with groundwater development over the past twenty years. The pattern of such developments has been almost consistently one of overdevelopment. The scale of development has been out of proportion to the groundwater stock and natural recharge. The result has been rapid mining and thus depletion of the stock. This pattern is seen in many areas overlying the Ogallala aquifer, particularly in the High Plains area with subareas facing the depletion of groundwater stocks within three years (*Albuquerque Tribune* 1976a). Depletion of groundwater stocks in southern Arizona has been the raison d'etre for the Central Arizona Project (Kelso, Martin, and Mack); depleted stocks have become an increasingly serious problem in western Kansas.[1]

The basic notion developed in this paper is that problems of the sort exemplified above might be avoided, or perhaps diminished, if at the outset groundwater development plans were considered in the context of the optimal steady-state level for groundwater stocks and rates of natural recharge. The "optimal steady-state stock" (denoted x^*) is the level of groundwater storage at which mining optimally ceases and withdrawals of groundwater are limited to natural recharge (w). If, prior to groundwater development activities, planners know x^* and w for a given aquifer, the following kinds of policy-related questions can be addressed.

Given alternative levels of development (permissible annual withdrawal rates), for how many years can these withdrawal rates be maintained? Or, given initial storage x_0 and the steady-state storage level x^*, the difference $x_0 - x^*$ can be mined (withdrawals in excess of recharge); for a given annual rate of mining (m), the number of years that m can be maintained is given by

$$T(m) = (x_0 - x^*)/m.$$

The annual rate of groundwater withdrawals (u) consists of mining and recharge, i.e., $u = m + w$. Each rate of mining analyzed above implies a number of years $T(m)$ for which that level can be maintained. For each m, what is the impact on local communities of use rates u over $T(m)$ years, and what are the impacts of water-use levels (which fall from u to w) at the end of $T(m)$ years? With prior knowledge that a use rate can only be maintained for $T(m)$ years, what sorts of legal-institutional arrangements might compensate for the eventual (inevitable) fall in economic activity at $T(m)$ when use rates decline from u to w? What might be the ramifications of establishing a system of water rights that expire, in a staggered fashion, through time?

O. R. Burt is a professor of economics and agricultural economics, Montana State University, R. G. Cummings is a professor of economics, University of New Mexico, and J. W. McFarland is an associate professor of quantitative and management sciences, University of Houston.

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[1] The overdevelopment of groundwater resources is certainly not a problem peculiar to the United States: Similar problems in Northwest Mexico are described in Cummings.

The questions given above are, of course, not comprehensive but are intended to be simply suggestive of the potential contribution to the process of water planning that estimates for x^* can make at the initial stages of groundwater development.

In the next section, the general methodology for determining such steady-state levels in natural resource systems is developed, and data from a case study of groundwater use in the Estancia Valley (New Mexico) are used to exemplify the usefulness of the approach (Cummings and Gisser). Concluding remarks are given in the last section.

Determining Steady-State Groundwater Stocks

The Conceptual Model

The basic structure of solutions for the optimal rate of extraction from natural resource systems has been the topic of a wide range of studies (see Burt and Cummings' bibliography) and can be heuristically described as follows. Given an initial resource stock, periodic extraction is carried to the point where the value of the last unit extracted "today" equals the marginal, or incremental, value of a unit of the resource in storage. The value of a unit in storage is measured by such things as increased costs "pushed forward" to all future periods and the value that the increment in storage can generate in future periods. With all future values discounted to the present, solutions for this class of problems normally involve high initial rates of extraction, with future extraction rates declining through time, eventually converging to the "flow" component of the resource system (natural recharge in the case of groundwater; convergence is to zero in the case of "exhaustible" resources).[2] The level of resource stocks that is obtained when periodic extraction rates equal the flow component of the resource system then remains constant into perpetuity. The resource system is said to be in a "steady state," and this resource stock that remains unchanged through time is called the steady-state stock. Thus, the solution to the dynamic optimization problem concerning the exploitation of a natural resource stock yields the steady-state stock and the time at which the system optimally enters the steady state.[3]

Solutions for dynamic optimization problems may become complex and costly and may be impossible to obtain with the amount of regional detail required by planners. This is particularly true in early stages of groundwater development where hydrological and agroeconomic data may be extremely limited. It is generally the case in early stages of groundwater development planning that the dearth of hydrological-agroeconomic data make efforts to apply "sophisticated" dynamic techniques a questionable exercise. Limited and weak data may be viewed as useful for only more cursory types of analyses. As shown in Burt and Cummings, however, it is possible to calculate the dynamic optimization problem's steady-state stock without going through the dynamic optimization process.

For a system characterized by a resource stock x and a single control variable u, define u as total periodic groundwater use (total pumping) and x as the groundwater stock. If $\phi(u, x)$ is net losses of groundwater stocks per period, changes in groundwater stocks obey the difference equation: $x_{t+1} = x_t - \phi(u_t, x_t)$. Let $G(u, x)$ measure periodic net incomes from groundwater use (e.g., net agricultural incomes from irrigation). As u increases, G increases. Higher levels of x imply higher values for G for reasons described above, e.g., as x increases, water tables are higher, pumping costs are lower, and net agricultural incomes increase.

The general structure for the steady state given by Burt and Cummings involves the simultaneous solution of the following equations (in what follows, G_u is used to denote $\partial G(u, x)/\partial u$, $G_x = \partial G(u, x)/\partial x$, etc.):

$$G_u = \frac{\phi_u G_x}{(r + \phi_x)} \tag{1}$$

and

$$\phi(u, x) = 0, \tag{2}$$

where r is the discount rate. If w measures periodic net recharge to the aquifer and net recharge is independent of stocks, net decline in the groundwater stock is given by $\phi = u - w$, and equation (2) reduces to the simple result

[2] It is important to recognize that natural recharge is not independent of surface water development decisions, and there is often an opportunity to deliberately enhance recharge such that, for the same total flow of water consumption, a greater proportion comes from groundwater (see Burt). The severe drought being experienced in the West dramatizes the virtues of relatively greater dependence on groundwater.

[3] Technically, in many cases the steady state is approached asymptotically, in which case time, as used above, is infinity.

$$u = w. \tag{3}$$

To derive the steady-state groundwater stock x^* from equations (1) and (3), one needs only estimates of $G(u, x)$, i.e., how u and x determine incomes, periodic recharge w, and discount rate r.

A simple extrapolation of pumping costs in a relatively high storage situation to a severely depleted one can be extremely misleading and even result in a negative value for x^* in the solution of equations (1) and (3). Two economic forces tend to make the marginal value of stocks increase rapidly as stocks are approaching exhaustion. First, wells will go dry in an irregular pattern because the water-bearing strata will not be of uniform thickness throughout the basin. Second, drawdown at the individual wells during peak demand periods will result in water shortages during the critical periods of the season, especially from the larger bore wells.

The first phenomenon means that the groundwater stocks' function as a distribution system increases rapidly as stocks accumulate from the zero level, while the second implies that the intraseasonal storage function of groundwater greatly improves as stocks increase from zero. Both of these economic considerations would tend to make G_x increase rapidly as x goes to zero and thus force an equilibrium solution to equations (1) and (3) involving $x^* > 0$.

An Application

To allow perspective as to the potential relevance of steady-state stock levels, a somewhat hypothetical characterization of groundwater use in the Estancia Valley (some 40 miles east of Albuquerque, New Mexico) is used as an example inasmuch as a recent study of that area by Cummings and Gisser provides data required to estimate $G(u, x)$.

Groundwater stocks in this essentially closed basin are currently some 2 million acre-feet,[4] with net annual recharge of 20,000 acre-feet. An estimate for net agricultural incomes based on budget studies of irrigated farms is given in Cummings and Gisser. This work permits calculation of the function G in tubular form. Using parametric linear programming techniques, these data are used to estimate a continuous form for G by least squares fitting of a polynomial:[5]

$$\begin{aligned} G(u, v, x) = {} & 2{,}512 + 13.3u - 0.1u^2 \\ & + 587.1v - 198.4v^2 + 0.73(uv) + 76.6x \\ & - 0.16x^2 + 57(ux) + 0.72(vx) - 45(u^2x). \end{aligned} \tag{4}$$

In equation (4), u is the rate of groundwater use (in acre-feet per year), x is groundwater storage (in millions of acre-feet), and v is amortized annual capital costs (million dollars). Capital is included in G to reflect the possibility of substituting capital for water as groundwater storage declines. Ideally, capital would enter the problem as a stock. So long as groundwater stocks change slowly, and amortized capital costs in turn change slowly enough that the implied capital stock can be depreciated at an economic rate consistent with the assumptions underlying the production function, the "flow" nature of v may be palatable.

The net decline in groundwater stocks in the Estancia Valley case is simply a function of annual withdrawals or, with annual recharge (w) of 20,000 acre-feet,

$$\phi(u) = u - 20{,}000. \tag{5}$$

Consider the following hypothetical problem. Suppose that existing irrigation in this Valley is from surface waters. As a result of energy developments in the Valley, or in other parts of the state, planners are considering the development of the Valley's aquifer as an alternative source of water for irrigation. Given the hydrological characteristics of the Valley and its aquifer, what level of development "should" be allowed?

Current storage of groundwater and annual recharge are known: $x_0 = 2$ million acre-feet and $w = 20{,}000$ acre-feet. The optimal steady-state stock—the level of groundwater storage at which annual withdrawals are optimally limited to recharge—is calculated using the equations (1) and (2), augmented by an

[4] This is water of class I quality (0 to 1,000 parts per million dissolved solids); for simplicity, stocks of lower quality water are ignored.

[5] In terms of fitting equation (4) to data from Cummings and Gisser, a least-squares fit of a general quadratic in the three variables was somewhat deficient. Third degree interactions were introduced into the polynominal, and only one term was of much consequence, namely, linear storage times use rate squared (u^2x). Although statistical measures are not very relevant in this type of curve fitting, the t-ratio on this interaction term was 9.4, and the adjusted R-squared went from 0.968 to 0.981 with the addition of this variable into the quadratic. Clearly, the level of capital interacts with groundwater stocks in a sufficiently complex way that a simple cross-product term is inadequate. To reflect the "uneven bottom" problem of the aquifer, the model is structured such that land available for irrigation decreases by 10%, 25%, and 40% as stocks fall from 2 million acre-feet to 1.58, 1, and 0.58 million acre-feet, respectively.

equation to account for the variable v, viz., $G_v = 0$. Values for x^* and v^* for various discount rates between 0 and 10% are given in table 1. These hypothetical planners now know x_0 and x^*, the difference between which defines the upper limit on groundwater mining. Thus, with $r = 5\%$, $x_0 - x^* = (2 - 0.295)$ million acre-feet, and annual groundwater use is limited to natural recharge after 1.705 million acre-feet has been mined.

What then are the ramifications of alternative levels of development in this Valley, where "levels of development" are represented by annual rates of water use? Suppose that one arbitrarily chooses for analysis the rates 83,000, 66,000, 56,000 (approximately the current rate of use in the Valley), 52,000 and 25,000 acre-feet per year. Approximations for the associated annual levels of net farm income, regional income, and the length of time that these income levels could be maintained before groundwater stocks fall to x^* can be found in table 2 for discount rates of $r = 0$ and $r = 5\%$.[6]

With the data in table 2, the following line of argument is available to the planner. Given a zero discount rate, and allowing for 83,000 acre-feet of water use per year, annual net farm and regional incomes will be on the order of $4.65 million and $14.88 million, respectively. But after five years, these income levels will fall to those associated with use rates set at natural recharge; i.e., annual net farm and regional incomes will fall to $1.1 million and $3.6 million, respectively. With $r = 5\%$, the higher income levels are maintained for twenty years. With levels of development associated with annual use rates of 56,000 acre-feet, net farm and regional incomes of $3.14 million and $10.05 million, respectively, are maintained for eight to thirty years with r between 0 and 5%.

Knowledge as to the optimum steady-state stock level thus places in perspective the magnitude and potential timing of changes in levels of economic activity inevitably associated with declining groundwater stocks, given alternative levels of groundwater development.

Table 1. Steady-State Groundwater Stocks and Optimal Levels for Amortized Annual Capital Costs for Selected Discount Rates

Discount Rate (r) (%)	Steady-State Groundwater Stocks (x^*) (Million Acre-Feet)	Optimal Levels for Amortized Annual Capital Costs (v^*) (Million $)
10.0	0.197	1.535
7.5	0.232	1.545
5.0	0.295	1.561
0	1.546	1.887

Note: Using G defined in equation (4), x^* and v^* are derived by solving the following system of equations: $G_v = 0$, $G_u = G_x\,(1/r)$, $\phi(u) = u - 20{,}000 = 0$.

[6] Net farm income estimates are based on net farm income per acre-foot of water use given in Cummings and Gisser (table 5 and C.5). These measures are not comparable with corresponding measures that one would derive from $G(u, v, x)$ in equation (5), inasmuch as Cummings and Gisser treat x as a constant. Regional incomes are derived by applying a regional multiplier of 3.2 to net farm incomes.

Concluding Remarks

Decisions as to the upper limits on groundwater development in any particular area are based upon the interplay of socioeconomic, legal, and political forces. With increasing water scarcity in the West, increasing attention will undoubtedly be given to the structure of legal and institutional arrangements that govern water use in general and groundwater use in particular, and the resulting processes of development and change will surely require more and better data.

An effort is made here to suggest and exemplify computational techniques that provide protagonists in this process of change with information that may be critical for evaluating alternative strategies for groundwater development. The lines of argument developed here parallel the general philosophy that underlies adaptive control processes developed in recent years. The notion of an adaptive control process centers on the information "feedback" that can occur over time with operational experience. Thus, in the case of groundwater development, one begins with limited hydrologic information that is often based on general information as to geological formations. Elementary hydrologic information is obtained only as drilling and pumping take place.

It follows that early estimates for groundwater storage must be viewed as tentative and subject to a process of modification as additional data become available. Such processes imply the need for relatively simple and flexible computational techniques, and a response to this need is the raison d'etre of the argument developed here.

Table 2. Net Farm and Regional Incomes for Alternative Annual Rates of Water Use and Associated Years Before the Steady State

	Annual Rate of Water Use (Acre-Feet)				
	83,000	66,000	56,000	42,000	25,000
Net farm and regional incomes (million $)					
Net farm income	4.65	3.72	3.14	2.33	1.40
Regional income	14.88	11.9	10.05	7.46	4.48
Years before the steady state with discount rate (r) of					
0%	5	7	8	11.9	18
5%	20	26	30	41	68

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Water Quality Management and Irrigated Agriculture: Potential Conflicts in the Colorado River Basin

John E. Keith

The enforcement of the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500) has been primarily directed at "point sources" of pollution, that is, those polluters whose effluent is easily isolated and identified such as municipalities and industrial plants. Violators have been fined varying amounts depending upon the frequency, extent, and type of violation. The long-run goal of the legislation is, however, to eliminate all man-caused effluent, to reach a zero discharge level of effluents for all activities. If or when these standards are applied to irrigated agriculture, several problems may appear, both in the attempt to enforce effluent standards and in the effect that enforcement may have on agriculture in general and irrigated agriculture in particular. Some of these problems are suggested in a general context; a detailed discussion of some of the possible impacts of water quality controls in the Colorado River Basin is then undertaken, with particular references to a zero discharge requirement.

General Problems

One overriding question that has not been addressed by PL 92-500 or similar legislation is whether or not water quality standards are desirable on any basis other than emotional. Clearly, for many activities and cases, the social optimum will include some level of pollution. Elimination of all externalities will undoubtedly result in lower production and higher prices for all these activities than would occur at a social optimum (Kneese and Schultze).[1]

There is doubt about the applicability of the standards to diffuse sources. The permit criteria specify point sources only. The act as passed required that if a point source (i.e., canal outflow, ditch, etc.) can be defined, or if the return flow is from more than 3,000 contiguous acres, the permit requirement applies. The latter portion of the act was voided in 1975, so that the permit requirement applies only to the point source criterion. Most irrigated agriculture involves diffuse sources of pollution in that no one polluter's effluent can be distinguished from other polluters. Given a zero discharge requirement, there are only a few enforcement options available: to monitor each farm's outflow of irrigation water, to require each farm to treat outflow, or to require the water distributing agency to monitor or treat outflows. These enforcement options for the most part ignore potential pollution of ground water reservoirs, and in some cases it is these aquifers that significantly affect water quality in downstream surface water, as the aquifer is drained by natural springs or seeps. Further, all of the options for enforcement are expensive to the enforcing agency, to the polluter, and in the long run to the consumer.

There are some provisions in PL 92-500 that may also affect changes in the structure of American agriculture. If diffuse sources fall under that act, the costs of meeting effluent standards appear to be a particularly large burden for smaller farms. The incentives exist to force small farms to either sell, consolidate farms, or reduce the size of the farms below the size to which pollution controls apply. The "family farm" may well become a garden plot for part-time farming operators.

Beyond the enforcement problem, the crucial issues about the application of water quality controls to agriculture are those of the economic efficiency and equity of imposing the standards on the agricultural sector. Will the

John E. Keith is a research assistant professor in the Department of Agricultural Economics, Utah State University.

[1] Kneese and Schultze treat the zero discharge portion of the bill as a relatively improbable goal. Recent passage of the Clean Air Act Amendment appears to indicate that the zero discharge mentality maintains a considerable influence over legislation.

additional costs to agriculture and consumers of agricultural products be less than the benefits generated by cleaner water? Will those who benefit be able to compensate those who lose? Probably, the efficiency questions can only be answered within the context of a specific river basin. On the other hand, by examining a river basin, some generalities with respect to efficiency and equity may be revealed. The Colorado River Basin is the basin chosen for analysis.

PL 92-500 and the Colorado River Basin

A full description of the institutional setting in the Basin is uncalled for. However, some of the institutions that play an important role in the use of the river may be affected by pollution controls. In general, western water rights are based on the appropriation doctrine; that is, first in time, first in right. Each state controls its allocation of water among users, subject to interstate constraints. Most states allocate water rights to those uses termed "beneficial" by the allocating agency. These water rights may or may not be appurtenant to the land and may be transferred more or less freely, depending on the state regulations.

Description of the Region

The Colorado River Basin is large and physically, economically, and institutionally complex. The river has its headwaters in Wyoming, Colorado, and eastern Utah and significant other feeder rivers from New Mexico, southern Utah, and Arizona. The agriculture in the region varies considerably. Irrigated crops in the Upper Basin states (Utah, Wyoming, Colorado, and New Mexico) are generally limited to alfalfa, wheat and other small grains, and silage corn. Some fruit is grown, as are sugar beets, in a few areas. The Lower Basin states have longer growing seasons, and many cash crops are included in the rotation. Citrus crops, lettuce, tomatoes, and a variety of other high-value crops are cultivated both in the Salt River Basin of Arizona and the Imperial Valley regions. Estimations of the value of the marginal product of diverted water in irrigated agriculture range from a maximum of about $35 and an average of about $10 for the Upper Basin states (Anderson et al.) to $70 to $75 maximum and about $30 to $35 average for the Lower Basin states (Kelso, Martin, and Mack; Hedges and Moore). Other estimates from earlier studies show somewhat less difference in value.

Two regional organizations, the Upper and Lower Colorado River Commissions, have some jurisdictional power, as do the seven states served by the river and its tributaries (including California and Nevada). The water allocation between the states is governed by two levels of compacts. The Colorado River Compact divides the water between the Upper and Lower Basins and stipulates a given amount of outflow (7.5 million acre-feet) at Lees Ferry, Arizona. The division of water rights among states is governed by another compact for the Upper Basin states and has been a matter of judicial decision and agreements between the Lower Basin states. In addition, water has been allocated to Mexico by treaty. Thus, the water in the Basin is totally allocated in an "average" year. Further, the agreements and adjudications that were made were based on a series of greater-than-average flow years, so that water has been overallocated for the past years of lower flow. The institutional framework, as will be shown, may impose constraints that conflict with the water quality standards, particularly the zero discharge requirements.

While many pollutants may be found in the effluent of users of the river, salt content is the main pollution problem. This discussion focuses on the salinity problem. While high salinity may be unique to the rivers of arid West, many of the potential conflicts between agricultural production and water quality standards for salinity are relatively broadly applicable.

The salinity problem does have one important aspect that may be atypical of all river basins that have irrigated agriculture—water quality conflicts. Much of the salinity in the Colorado River is a result of natural sources rather than of man's activities. Some disagreement exists among researchers with respect to the amount of salt contributed by the natural sources; a few researchers estimate the natural loading to be from 30% to 40% of the total salt content, while others estimate as high as 75% of the salt is contributed by natural sources. Estimates made by Utah State University researchers indicate 26% or 702,300 tons of salt out of 2,676,000 total tons are contributed by irrigated agriculture in the Green River Subbasin; for the Upper Main Stream of the Colorado, 1,374,760 tons or 27%

of the 5,012,000 tons were from agriculture; for the San Juan Subbasin, 232,000 tons or 23% of the 1,010,000 tons were from agriculture; for the Lower Main Stream, 273,500 tons or 31% of the 882,260 tons were from agriculture; and for the Little Colorado River Subbasin, 18,550 tons or 16% of the 116,300 tons were from agriculture. Clearly, a major portion of the salinity problem cannot be attributed to irrigated agriculture.

The Effect of Water Quality Standards

Given the physical and institutional settings of the Colorado River Basin, what can be expected if water quality standards are imposed on irrigated agriculture? The first, and possibly the most critical, problem will be the enforcement of the standards in general and the zero discharge requirement in particular. Quantifying pollutants from each point source will require a monitor for every farm, if not by the enforcement agency then by the water distributing agency whose discharge in turn is monitored, in order that the cost of treatment (or fines) can be adjudicated. Monitoring groundwater return flows, which add considerable salt to downstream flows, would be economically infeasible if not physically impossible.

Second, if meeting the standards is expensive, particularly if the cost of monitoring is borne by farmers, then any loopholes that would allow escape from the standards will likely be implemented. For example, if irrigation canal return flows from a farm can be considered a point source, the farmer will likely adjust his irrigation practice to avoid the effluent point or conveyance. Natural seepage or water-spreading practices may replace concrete ditches returning water to larger irrigation canals. If fines are very heavy, as the law states ($5,000 for the first offense and up to $50,000 per repeated offenses), it seems likely that ponding or water spreading would be a cheaper alternative to a monitorable point source. Adding to the return flows to groundwater may increase the salt load, depending on the salt content of underlying strata. In much of the Upper Colorado Basin, impervious, salt-laden shale strata cause groundwater flows to pick up heavy salt loads, which often augment downstream surface water through springs and seepage. Thus, water quality controls may lead to a worsening of stream quality in lower reaches.

If the zero discharge standards are imposed on canal companies, as seems more probable given the magnitude of effort required to monitor each farm, then it appears likely that canal companies will be forced to construct end-of-pipe treatment plants. These plants will be quite complex, since pesticides and fertilizers will have to be removed along with the salt load. Current treatment costs for municipal effluent (biological oxygen demand, coliform, etc.) average between $25 and $50 per acre-foot.[2] The estimated cost of a desalinization plant is about $33 per ton of salt removed (Kleinman, Barney, and Litmus) or an average of about $80 to $85 per acre of irrigated cropland for the Colorado River Basin. For municipal treatment facilities, as plant size decreases unit treatment costs rise. If decreasing costs to scale also hold for desalinization, a small irrigation company would likely have extremely high treatment costs. Given current values of irrigation water in both the basins, a significant burden would be placed on agriculturalists. The construction and operation of treatment plants will likely have to be publically financed, with a payback procedure similar to the construction of irrigation dams and canal systems. Further, the fees levied on water users would likely be based on water diversions, rather than on effluent levels, because of the high cost of monitoring each farm in a system and because individual farms might avoid the effluent charge by the ponding or spreading techniques discussed above. This system of charges could be both economically inefficient and inequitable. In fact, such a distribution of charges could lead to encouragement of pollutant production (particularly fertilizers and pesticides), given the common property aspect of the treatment plant ownership.

There are some on-farm technological adjustments that can be made to reduce the pollutant levels of surface water. First, farmers can change their irrigation system to sprinkling. Second, farmers can develop a total containment approach similar to the measures planned by the steam-powered electrical generation and mining companies. The shift to sprinkling irrigation can reduce salt loading by a substantial amount, depending on rates of application and crop rotations (Hanks et al.). Several problems arise with sprinkling irriga-

[2] Current sewage treatment plants are not capable of removing these pollutants.

tion, however. Although salt outflow may be decreased, it is not eliminated by sprinkling.

There is a buildup of salt in the root zone with sprinkling, unless sufficient water is used to "flush" the salt out or unless tile drains are used to prevent capillary effects from bringing salt to the root zones. Even tile drains will not prevent salt buildup where irrigation water is already salt laden. Clearly, flushing would violate water quality standards and zero discharge almost by definition. If the surface is tile drained, the additions of salt to groundwater and thence to surface flows may be eliminated and the surface effluent managed. However, the imposition of zero discharge could eliminate the use of the drains even in the areas that have adopted the practice, since these drains can be identified as point sources. Without flushing or tile drains, yields and profits will decline substantially over time. This reduction in profitability has a compounding effect. Most studies show that, in order that sprinkler irrigation be as profitable as flood irrigation, rotation must change to include more intensive, higher valued crops (Meale, Cannon). Otherwise sprinkling yields either low or no profit, since the capital requirement is very high. Many of these high-valued crops in the Upper and Lower Basins are salt sensitive. Thus, if water quality constraints eliminate flood irrigation and force zero-discharge sprinkling, irrigated agriculture may have a limited role in at least the Upper Colorado Basin in the long run. The extent to which irrigation will continue in the Lower Basin is uncertain simply because of the higher valued crops. It is doubtful that marginal land could sustain the added costs of sprinkling, tile draining, or water treatment.

The alternative to sprinkling is total containment. Ponding for evaporation would be relatively inexpensive. Some have suggested that reuse of ponded water would reduce the effluent problem as well. Unfortunately, at least in large parts of the Basin, ponded water would be salty enough to inhibit production. In fact, many of the potential industrial users indicate that reuse of Colorado River water for cooling is questionable due to its high salt content.

The constraint on total containment by agriculturalists is neither economic nor technical. The institutional framework may prevent the practice for current levels of irrigation. The Colorado River Compact establishes the outflow required from the Upper Basin; similarly, the Mexican Treaty establishes outflow for the Lower Basin. If farmers pond water, there will be a reduction of flow in the river, since current consumptive use is about 50% to 60% of diversions in most areas of the Upper Basin. The return flows from agriculture would be reduced by about half in the Upper Basin and probably by the same percentage in the Lower Basin. Total containment could not be accomplished without some transfer of water rights, even within each state. Several of the states have either state laws or judicial decisions that require maintenance of downstream flows (return flows). There is obviously a "taking" of water rights involved with containment, although market compensation might be the method by which total containment could be practiced by a reduced number of irrigators. Even with total containment, water quality could decline in the Colorado River due to reduced dilution. Where high quality groundwater is used for irrigation, those flows would not augment the river. In fact, the likelihood of developing groundwater for new irrigation will be significantly reduced due to the zero discharge limitations. Those areas that have been developed, or are planned, using saline groundwater for irrigation would very likely have to be abandoned.

The total containment problem points out another weakness of PL 92-500 in situations similar to the Colorado River Basin. Water quality is a function of both pollutant loading and of dilution by additions of relatively clean water. The reduction of high quality return flows in areas where high levels of natural loading occurs may well cause a degradation of stream quality. Imposition of rigid standards like zero discharge could reduce the quality of the Colorado River as a result of wide-scale adoption of total containment by irrigators. At the very least, it is not certain that such standards will improve water quality.

Other technological controls have been suggested. Canal lining and selective retirement of irrigated land have been discussed. These two approaches will have some moderating effect of salt loading in the Colorado River, but only a small portion of the salt loading could be reduced (Utah State University). In addition, canal lining would probably cause significantly more water to require treatment, since seepage does reduce the amount of surface flows that can be identified as point sources. The incentive might be not to line

canals in order to avoid the treatment costs.

From the foregoing discussion, it seems possible that the implementation of water quality standards, especially zero discharge, in the Colorado River Basin may have a large detrimental effect on irrigated agriculture in both Lower and Upper Basins. In addition, the incentive to avoid the standards could lead to decreased water quality. The fundamental economic question is if benefits are gained, are these benefits greater than the implementation costs, and could those who benefit compensate those who lose?

Benefits and Costs

A general theoretical treatment of the externalities of pollution leads to the conclusion that, unless the pollutant is extremely harmful in very small concentrations, the social optimum will occur at a point where some externality exists (for example, Buchanan and Stubblebine). The zero discharge requirement is too restrictive, but the intermediate standards—best practical technology and best available technology—may also be too restrictive with respect to a social optimum. Figure 1 illustrates the economically efficient reductions in agricultural loading, where the marginal damage avoided just equals the marginal cost of control at R^* (Gardner and Stewart). For the Colorado River Basin, upstream salt loading has been the cause of downstream cost to municipal, industrial, and agricultural water users.

There have been several estimates of the reduction of downstream damages, given reduced levels of salinity at Imperial Dam. These estimates range from about $50,000 per year per milligram per liter (U.S. Environmental Protection Agency) to $250,000 per year per milligram per liter (Kleinman, Barney, and Litmus; Valentine). The costs of reducing the salt loading vary substantially. Some methods appear economically reasonable, some do not. The cost of conversion of agriculture in the Basin to sprinkler irrigation is estimated at between $1 and $4 million per year per diminution of one milligram per liter (Utah State University). Clearly, a large cost must be borne by upstream irrigators compared with a relatively small downstream benefit. Further, these values are averages; it is likely that some conversions to sprinkling might generate benefits equal to costs at the margin, but total conversion would pass the point of equal marginal cost and benefits, since marginal benefit would be expected to be falling or constant while marginal cost would be expected to be rising. Other methods, such as canal lining and irrigation retirement plans, have average costs approximately equal to the average benefit. These programs would not reduce the salinity by a great deal (perhaps 10%), yet these appear to be the economically feasible projects. Thus, the existence of externality costs at the social optimum is probable; however, the optimal level of upstream treatment is currently unknown. The same kinds of arguments may well apply to outflows to Mexico from the Lower Basin. Where the social optimum lies is subject for further empirical research, but it is almost assured that the social optimum in this case does not occur at zero discharge.

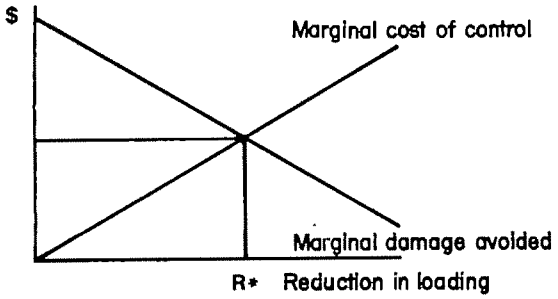


Figure 1. Optimum level of loading reduction

It has been shown that in at least one small Colorado River subbasin, the Virgin River Basin, significant reduction in salt loading requires a substantial diminution in irrigated agricultural acreage. This subbasin is relatively typical, with saline springs and erodable soils that contain moderate to high salt concentrations. In fact, the Virgin River Subbasin has less salt in the soil than the Mancos shale soils of the Cisco, Utah, region. Results of an interfaced hydrosalinity and linear programming model indicate that, in order to achieve a less than 10% reduction in salt loading for the subbasin, an almost 50% reduction in irrigated agriculture is necessary (Keith et al.). Foregone net returns to irrigated agriculture amount to a minimum of $1,000,000 to reduce the salt concentration by not more than 2 milligrams per liter at Imperial Dam. One implication that may be derived is that the social optimum probably would occur at a considerably less stringent controls than zero discharge.

Some Future Consideration

The Upper Colorado Basin contains energy resources that are currently being exploited or whose exploitation is being planned. While energy is not the subject of this paper, there may well be a significant impact on irrigated agriculture as energy develops and responds to water quality standards. First, the energy developments, including steam-powered electrical generation plants, oil shale development, coal mining, and synthetic fuel plants, will all be point sources; therefore, each will be subject to monitoring and the current permit system. Because of the high cost of treating water high in salt, current plans include total containment of waste water from both processing and cooling activities. Since all the water in the Upper Basin has been allocated, these energy developments will be forced to acquire water from current holders of water rights either by reassignment by the appropriate authorities or by purchase. Given the constraints on return flows, these energy producers will have to obtain diversion rights sufficiently in excess of their consumptive use that remaining downstream users have sufficient water available. Thus, less irrigated agriculture will exist than would be the case under less stringent water quality standards. In fact, the Colorado River Assessment Study (Utah State University) indicated that with the development of energy resources less loading will occur as irrigation is reduced, but concentrations will rise as a result of increased consumptive use of water in the total containment activity.

There are also some side issues with respect to municipal waste treatment, both for current residents and future populations of the Basin. There is considerable evidence that effluent from many municipalities is undetectable a short distance downstream from their discharge points. The existing regulation will require large investment in sewage treatment plants by those municipalities. This burden will fall more heavily on smaller communities that generate relatively less effluent than larger metropolitan areas. The water quality standards approach ignores both the substantial costs and the practically nonexistent benefits of pollution control for these municipalities.

There are also several planned water exports in the Upper and Lower Basins. While these exports are not identified as point sources of pollution, they may well have significant impacts on the water quality in the river. As water is withdrawn from the river, less dilution of the salt load takes place, and the concentration rises. These exports may be more significant to water quality than loading from either the agricultural or energy sectors, yet PL 92-500 will have no regulating effect.

[3] Consumptive use may be as low as 30% to 40% in some parts of the Upper Basin.

Summary and Conclusions

The application of water quality standards to irrigated agriculture will be, at best, difficult. Whether the law even applies to most irrigated agriculture is open to question. The ability to identify the sources of effluents or to monitor identified sources is doubtful. If the standards are applied, agriculturalists will have to alter their current practices and may be forced to cease irrigation due to economic infeasibility of meeting standards, particularly the zero discharge requirements. In addition, the benefits gained to downstream users will likely be much smaller than the costs borne by upstream users for achieving zero discharge. Irrigated agriculture will not be the only sector that is affected; the imposition of the rather arbitrary standards, including eventual zero discharge requirements, will impose very high costs on small rural municipalities in the Basin with little or no detectable improvement in water quality in the river. With the advent of energy development and large water transfers, the effluent standards may, in fact, worsen the water quality.

Apparently, PL 92-500 is an ill-conceived approach to the water quality problems that result from irrigated agriculture. Given the importance of irrigated agriculture to the West, the "legalistic" physical standards approach may lead to a loss in social welfare rather than a gain.

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Discussion

Norman K. Whittlesey

The paper by Robie is primarily a series of observations of legal, economic, and institutional problems highlighted by a recent two-year drought. Apparently, the abilities to adjust to lower water supplies exceed the previous expectation of most people. This result should not have been surprising since much of the arid world survives very well using much less agricultural and municipal water than we do.

Any thoughtful economist should have anticipated that water use will be high when it is cheap and plentiful and that, even in the short run, adjustments can be made to raise the average productivity of water as it becomes more scarce. Robie expressed surprise at the willingness of farmers to pay more than $40 per acre-foot for water. However, in a longer run setting, we should expect such a phenomenon to be common with concomitant adjustments in other resource values, particularly that of land. As time passes and the opportunities and incentives for adopting different technologies and management practices are presented, we should expect the ability to survive with less water to improve significantly. What we have seen are normal adjustments to a resource having greater relative scarcity.

On further thought, we should not be so surprised by a drought of this length or severity when our experiences into the past are so brief. Archeological research collecting weather information from the past 5,000 years has shown that equally or more severe droughts have persisted for periods of twenty to forty years. Thus, scientists, including economists, should expand their thoughts and research to consider the necessary preparations for and potential adjustments to such a phenomenon. We might take heed of Kelso's comments in the fellow's lecture and make plans that do not require using all available resources all the time.

The paper by Burt, Cummings, and McFarland provides an analytical construct for estimating optimal rates of groundwater mining. The authors use linear programming to generate data for a function that in turn estimates income for alternative levels of capital stock and groundwater withdrawal rates. They show that, as the discount rate goes up, there is a greater willingness to mine the groundwater and capture its value in the present rather than preserve the water for future use. The higher the discount rate, the more mining that is allowed before the desired steady-state level of groundwater stocks is achieved.

While this is a neatly packaged device for generating such information, the result is exactly what one should expect. So, while the Burt, Cummings, and McFarland procedure or others could be used to provide this kind of information, there remains the important question of how it can be put to use. It is not obvious how local or state policy makers are going to be led to the optimum discount rate or rates of declines in the static water level. Those who ultimately choose discount rates and, in turn, the rate of groundwater mining are often politically elected or appointed. This leads to a very short planning horizon and implicitly imposes a high discount rate on the decision process. The result too often is to exhaust the resource in a relatively short time period in order to satisfy the short-term demands of political constituents. The opportunities for using the water are eliminated for the future when societal needs for potable or fresh water may be much greater than at the present. Kelso's reversability criteria are violated.

Some factors that need consideration in a water-mining situation but not adequately discussed in this paper include: capital assets should not require more rapid depreciation due to declining water levels than their normal wear-out period; the impact of rising energy costs or energy shortages anticipated for the future should be considered; and, importantly, the application of such information cannot be left entirely to the ingenuity of policy makers. It would be interesting and useful to attempt to calculate the optimal discount rate for satis-

Norman K. Whittlesey is a professor of agricultural economics, Washington State University.

fying long-run societal needs in such a setting. There are remaining questions of who gets to capture the wealth from the water, how to tax its use, and who should be the last (first) to quit pumping. It seems that the present laws for water appropriation in the West are no longer adequate for allocating scarce groundwater resources that properly belong to all of society. These are problems that have largely been left to the politicians and institutions. The economist could offer much more than in the past.

Keith properly identifies the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500) as having been directed at "point sources" of pollution. However, he proceeds to assume that the same standards will automatically apply to irrigated agriculture. It is my understanding that the rules, standards, and methods of enforcement that may eventually be applied to irrigated agriculture are yet to be determined. While there undoubtedly will be increased attempts to reduce the pollutants associated with irrigation return flows, the methods of achievement and levels of abatement are yet unknown. Certainly the assumption of zero discharge is not valid at this time.

We should dismiss zero discharge as a constraint on agricultural water use and proceed to consider more realistic solutions to this problem. It is most likely that such things as appropriately applied best management practices or best available technology will ultimately lead to the desired societal solutions. This attitude then opens up the possibility of a number of economic, legal, and institutional instruments to influence pollution abatement, which went unconsidered by Keith. These include taxes on inputs such as water and fertilizer, bribes (compensation) to influence the choice of irrigation system, water rationing, and constraints on crop selection for specific soil types or slopes, to name a few. Certainly, little pollution abatement can be achieved without imposing some costs on some segments of society. However, research in the Yakima River Basin of eastern Washington indicates that up to 50% of current levels of pollution from irrigation return flows can be abated at relatively low cost to society. Abatement levels greater than 50% will face rapidly increasing costs, and the distribution of these costs will depend upon the method(s) employed to effect the control and the estimated distribution of benefits derived. Of course, the experience of each irrigated area will differ.

Another fundamental error underlying some of the conclusions by Keith is the assumption that irrigation diversions will (or must) remain constant following the achievement of improved water use efficiencies on the farm. The movement to better management or more efficient irrigation systems need not result in less water in the Colorado River. The dilution effect of reduced diversions could be very helpful in achieving desired improvements in water quality.

Keith does properly recognize the importance of measuring the benefits from pollution abatement as the relevant criterion for determining the desired level of abatement. This is an area lacking the proper attention of economists to date. We have focused elaborate models on the cost side of environmental improvement without adequate regard for the benefits to be derived from such activity. Until we provide decision makers with better measurements of such benefits, there will continue to be controversy over determination of the proper level of abatement. A representative of the Sierra Club or Friends of the Earth will most certainly have a different view of what should be achieved than a representative of the agricultural sector. Thus, I would encourage any efforts that will provide a better assessment of the benefits to be derived from abating pollution from irrigation return flows. The choice of abatement levels and the distribution of their costs would then become much easier.

The Recent Performance of Rural Financial Markets
(Dale W. Adams, Ohio State University, Chairperson)

Agricultural Credit Policy in Brazil: Objectives and Results

Paulo F. C. de Araujo and Richard L. Meyer

A number of developing countries have stressed credit policies to achieve agricultural goals. It is frequently difficult, however, to evaluate their effect because the amount of funds involved has been small or their impact has been masked by other development policies. The Brazilian case is revealing because huge amounts of credit have been channeled to agriculture, and credit policy stands out as a key component of agricultural policy. Thus, the Brazilian experience provides insights into what countries might expect if and when they assign credit policies such an important role. Furthermore, commercial banks have been used almost exclusively to supply the credit rather than creating new specialized agricultural credit institutions. Thus, the Brazilian case provides some evidence into how an existing banking system can be used to service agricultural credit needs in a developing country. This paper analyzes Brazilian policy objectives and the impact of credit on agriculture.

Brazilian Agricultural and Credit Policies

Like many Latin American countries, Brazil has heavily regulated its financial markets in pursuit of development goals (Eckaus). It is unique, however, because of the energy and initiative with which it has pursued conventional and innovative prescriptions in the financial sphere (Yusuf). Portfolio ceilings and quotas, discount mechanisms, and reserve requirements have been extensively employed to affect bank behavior in developing countries (Johnson). These methods plus interest rate controls and regulations on bank mergers and expansion have been used in Brazil. The usual indirect mechanisms of monetary control have also been used to influence the supply of credit.

Brazilian objectives for this intervention include modernization and increased efficiency in banking, enlarged financial services to less developed regions, and increased capital availability for particular sectors including agriculture. The strategy explicitly attempts to alter bank behavior through selective controls so resources flow to socially desired sectors and activities. The magnitude and comprehensiveness of the strategy suggests a "supply-leading" relationship between financial and economic development (Patrick).

The institutional credit system for agriculture consists largely of private and "official" banks (Meyer et al.). Official banks have various degrees of state and federal government ownership and capital and hold public sector deposits. The National Monetary Council and Central Bank created in 1964 provided the federal government with an effective means to control bank behavior. Furthermore, a large part of agricultural credit comes from funds administered by the Central Bank and/or the federal Bank of Brazil.

The stated objectives of agricultural credit were established in 1965 by the Agricultural Credit Law 4829: (*a*) finance a portion of operating costs of agricultural production and marketing, (*b*) stimulate capital formation, (*c*) accelerate the adoption of modern technology, and (*d*) strengthen the economic position of farmers, especially small and medium ones. An implicit but very important objective ap-

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Discussants for this session were Chita Subido of the Central Bank of the Philippines, Manila, and Chester B. Baker of the University of Illinois.

Paulo F. C. de Araujo is an assistant professor, University of Sao Paulo, Brazil, and Richard L. Meyer is an associate professor, The Ohio State University.

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pears to have been the use of credit subsidies to compensate farmers for the price and exchange rate controls designed to stimulate industrialization and control inflation. Moreover, credit policies have been used to address short-term problems like high fertilizer prices and the 1975 coffee freeze. Combining credit controls with product pricing policies has resulted in a comprehensive system for influencing factor use and output in agriculture.

A vast number of rules, regulations, programs, and subprograms have been applied to agricultural credit. Each program has specific objectives, interest rates, and repayment schedules. Three general features of agricultural credit policies need to be emphasized. First, nominal interest rates have been controlled at rates lower than those permitted for other loans. During the last decade, these controls resulted in negative real rates of interest (i.e., nominal interest rates lower than the rate of inflation). Second, incentives and controls have been used to induce banks to lend more of their own deposits and/or government funds to agriculture. Third, nominal interest rates for small loans (supposedly made to small farmers) have been set 1 or 2 percentage points below large loans.

Credit and Performance of the Agricultural Sector

The first major result of Brazilian credit policies has been a sharp expansion of formal credit supplies. Table 1 shows loans made each year and agricultural production for the 1960–75 period. Columns 1 and 2 list operating loans, usually with terms of less than a year, which represent about half the number and value of loans made in recent years. The remainder of the credit is split between marketing loans[1] with terms of a few months and investment loans payable over several years.[2] In this period, agricultural output rose 2.3 times. New loans made per year rose almost 15 times. The ratio of operating loans to agricultural output (column 6) rose from 0.07 in 1960 to 0.27 in 1974, while the ratio of total loans to output rose from 0.13 to 0.59. In 1975, the first ratio jumped to 0.37 and the second to

[1] Substantial amounts of marketing loans go to individuals other than farmers. Thus, column 2 underestimates the total short-term credit obtained by farmers, while column 4 overestimates total credit.

[2] Little institutional credit is available for farm real estate mortgages, so investment loans are lent largely to finance machinery, livestock, and perennial crops.

Table 1. Agricultural Credit and Output, Brazil, 1960–75

	Loans Made During Year[a]				Net Internal Product from Agriculture in 1975 Cruzeiros[d,e]	Ratio of Operating Loans to Product (2/5)	Ratio of Total Loans to Product (4/5)
	Operating Loans[b]		Total Agricultural Loans				
Year	Number[c] (1)	Value in 1975 Cruzeiros[d] (2)	Number[c] (3)	Value in 1975 Cruzeiros[d] (4)	(5)	(6)	(7)
1960	112	3,180	231	6,176	46,493	0.07	0.13
1961	184	3,280	285	6,157	48,252	0.07	0.13
1962	337	4,910	441	8,382	57,023	0.09	0.15
1963	416	4,410	549	7,267	50,182	0.09	0.14
1964	527	6,560	771	9,864	50,521	0.13	0.19
1965	509	5,730	666	8,483	56,875	0.10	0.15
1966	529	6,700	856	11,539	50,281	0.13	0.23
1967	633	9,040	1,029	14,925	53,415	0.17	0.28
1968	733	11,470	1,500	21,019	53,485	0.21	0.39
1969	675	9,624	1,145	20,718	56,737	0.17	0.36
1970	649	10,992	1,191	24,648	64,439	0.17	0.38
1971	686	12,394	1,253	28,481	76,126	0.16	0.37
1972	687	14,706	1,266	35,321	82,608	0.18	0.43
1973	771	21,288	1,400	49,852	95,996	0.22	0.52
1974	789	27,757	1,450	61,648	104,155[f]	0.27	0.59
1975	1,076	39,446	1,856	89,997	107,801[f]	0.37	0.83

[a] Source: Various Central Bank and Bank of Brazil reports (Brazil, Banco Central). Figures represent number and value of new loans made.

[b] From 1960 to 1968, the estimates for operating loans are based on loans made by the Bank of Brazil, which was responsible for the majority of agricultural credit lent during the period.

[c] Thousands of loans.

[d] 1 million cruzeiros. Values adjusted by the index "2" of *Conjuntura Economica* (Brazil, Fundacao Getulio Vargas).

[e] Source: Brazil, Fundacao Getulio Vargas.

[f] Projected from the 1973 figure by compounding a 8.5 growth rate for 1974 and 3.4 for 1975.

0.83 due in part to major funding for drought relief and coffee recuperation. These ratios are among the highest found in most other Latin American countries in the late 1960s (Adams).

Piza compares the indebtedness of agriculture relative to other sectors. He found the credit to output ratio for agriculture grew much faster in recent years. Although Brazil's general economic development strategy is oriented towards accelerating development through financial means, the agricultural sector has been especially favored with subsidized credit.

No comprehensive study exists on agricultural capital formation. Schuh cites data suggesting the structure of farm capital shifted away from real estate between 1940 and 1965, while the share in equipment rose. The 1970 census shows that land and buildings represented 68% of total capital assets, 18% in productive and work animals, 9% in permanent crops, and 5% in farm machinery and vehicles (Brazil, Fundacao Instituto Brasileiro de Geografia e Estatistica). It appears that the value of land and buildings still commands a large share of farm capital because of increases in farming area and land prices. Some of the rapid increases in credit may have been capitalized in land prices.

Credit policies have encouraged the adoption of both biological and mechanical technology. Programs have been introduced to finance so-called "modern inputs" including improved seeds, fertilizer, lime, agricultural chemicals, and livestock rations. Nominal interest rates have varied from 0 to 7% much of the time. Likewise, purchasers of domestically manufactured machinery have benefited from five- to eight-year loans with nominal interest rates ranging up to 15%, occasionally with a two-year initial grace period. Chemical fertilizer use rose from 380,000 metric tons in 1966 to more than 2 million in 1976 (Araujo et al.). Allegedly, the quantity of fertilizer supposedly financed in some regions has exceeded the amount actually sold. Domestic tractor production per year grew from 6,300 units in 1967 to over 62,000 in 1975 (Brazil, Instituto de Economia Agricola).

For the census, farmers reported investing Cr$4.4 billion (in cruzeiros) in on-farm investments in 1970. Of this total, Cr$2.2 billion was spent for machinery, livestock, and permanent crops, all of which were eligible for credit. The Central Bank reported Cr$2.5 billion in new institutional loans for agricultural investments that year (Brazil, Banco Central). Over 50% of the investment loans were reported for machinery purchases, and almost two-thirds of these loans were made in the states of Rio Grande do Sul, Parana, and Sao Paulo, which accounted for over 75% of the tractors reported on farms in 1970. It is quite likely, then, that credit for investment has been highly correlated with new machinery purchases. This conclusion is consistent with the tractor demand model estimated by Sanders for 1950–71. The variable for real value of tractor financing overshadowed the variable measuring tractor price relative to agricultural wage rates.

Distribution of Farms and Credit

Table 2 shows the size distribution of farms as reported in the 1970 census.[3] The total number of farms increased from 3.3 million in 1960 to 4.9 million in 1970, while the total farm area increased from about 250 million hectares to almost 295 million. Over a million new farms were added to the less than 10 hectare group, while the average size decreased from almost 4 to 3.6 hectares. The inverse relationship between farm size and value of production noted in several countries was found in Brazil in 1970. The first two size strata represented 90% of the farms, 23% of the area, and 58% of the production. Units of 10,000 or more hectares represented less than 0.1% of the farms, 12% of the area, but only 2% of the production.

Surprisingly, almost 90% of the Brazilian farms reported no credit from any formal or informal source in 1970. Even allowing for possible data limitations in the census, credit use was much less widespread than anticipated. About one-fourth of the farms in the upper three size strata reported receiving loans. Only 5% of the farms in the smallest strata reported loans. Thus, over 90% of all farms in the country were still untouched by credit programs in 1970.

Table 2 also reports the distribution of total volume of credit. Government entities provided almost 80% of the Cr$4.1 billion in credit reported in 1970. The two smallest farm size strata received far less credit than their share of farm numbers, while the three larger groups received far more. Considering farm area,

[3] See footnote b, table 2, regarding the definition of a farm used in the census.

Table 2. Distribution of Farms and Value of Credit Received, Brazil, 1970

Farm Size Strata (Ha.)	Farms	Area[a]	Production	Sources of Credit: All Sources	Individuals	Government Entities	Private Entities
				%			
Less than 10	51.1	3.1	17.8	5.5	13.2	4.2	8.5
10 to less than 100	39.3	20.4	40.0	33.1	35.1	33.4	29.4
100 to less than 1,000	8.4	37.0	29.3	41.8	30.5	44.2	34.0
1,000 to less than 10,000	0.7	27.2	10.7	15.6	15.9	15.2	18.0
10,000+	<0.1	12.3	1.9	4.0	4.4	2.9	10.0
No farm size reported	0.4	—	0.3	0.1	0.9	0.1	0.1
Total	99.9	100.0	100.0	100.0	100.0	99.9	99.9

Source: Brazil, Fundacao Instituto Brasileiro de Geografia e Estatistica.
Note: In the Brazilian census, farms are defined as "establishments" (Brazil, Fundacao Instituto Brasileiro de Geografia e Estatistica). A farm is a unit with one or more adjacent parcels under a single administration. Two nonadjacent parcels are treated as separate farms even if they are under a single administration. Likewise, parcels are treated separately even though owned by the same person if they are rented or sharecropped to two different persons with separate administration.
[a] An unknown bias exists in these data due to the farms not reporting size.

however, the first three strata received more credit than their land share. Considering value of production, the two smallest strata received less credit than warranted by their production, while the 100 to 1,000 group appeared to be especially favored with credit from government entities. Thus, according to the 1970 census, Brazilian policy makers had not succeeded in increasing agricultural credit for small farmers.

An analysis of the regional distribution of credit showed that approximately 75% went to more commercialized agricultural regions. Farmers in the state of Sao Paulo alone produced over 20% of the 1970 agricultural output and received one-fourth of total credit. Estimates of that state's credit to output ratio were even higher than for the rest of the nation. Results from farm surveys suggested that the state was increasing the share of credit going to small farmers.

Conclusions and Implications

Brazilian policy makers have established a complex set of controls and incentives to increase the quantity and lower the cost of agricultural loans. The volume of formal credit lent to farmers has sharply increased. But most farmers still do not receive credit, and the amount going to small farmers is especially low. Agricultural output and the use of some modern inputs have expanded. However, since value of production is a criterion for lending, it is difficult to establish a clear line of causality between credit and agricultural performance. There probably has been some substitution of external for internal funds.

The banks' response to the distortions introduced in the financial market is understandable. Compensating balances and noninterest costs and fees are widely used to increase returns from agricultural loans. Banks with a clear profit orientation have been especially reluctant to increase long-term agricultural lending. Loan procedures are cumbersome and increase borrowing costs.

Two important unanswered questions exist regarding the Brazilian experience. First, what would have been the demand for credit if agriculture would have been less discriminated against through price controls, overvalued exchange rates, and export controls? Second, would bank performance have been better, especially on equity grounds, if there would have been more incentives for agricultural lending? The two questions appear to be related. A justification for subsidized interest rates is to offset the discrimination of other policies. But interest rate controls reduce bank profitability. Thus, a logical tendency by banks is to reduce costs by lending to large farmers and to use nonprice methods to allocate credit.

Commercial banks can play an important role in financing agriculture in developing countries. The Brazilian experience suggests that establishing an appropriate set of incentives is crucial in affecting bank behavior. Flexible interest rates and simplified lending procedures are essential. General lines of credit should be created to meet agricultural development objectives. A special line of

credit, including loans for land purchase, is probably required if the economic position of small farmers is to be improved. However, the proliferation of specific credit programs to resolve specific short-term agricultural problems must be avoided.

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Credit Policies and Rural Financial Markets in Bolivia

Jerry R. Ladman and Ronald Tinnermeier

The early works of Patrick, Gurley and Shaw, and more recently McKinnon and Shaw stress the important role of financial markets in influencing the extent and pattern of economic development. Adams and Gonzalez-Vega were early authors to examine the specific role of rural financial markets (RFM's) in mobilizing savings from and delivering credit to farmers in less developed countries. There are three major separate but interdependent roles that RFM's are expected to perform: mobilize rural savings, allocate credit among productive activities in agriculture, and integrate the RFM's with the capital markets of the rest of the economy and the world. Often a fourth role of income distribution is added, i.e., ensuring that credit is directed to the potentially viable small farmer.

The development of Bolivian RFM's in many ways serves to illustrate not only the nature of the institutional and structural unfolding of RFM's in the course of modern day development but also to show how well-intended policy measures—many of which were induced by foreign donors and have been rather ubiquitously applied throughout the third world—have been inadequate and often have led to what are considered undesirable results especially in directing credit to the target group of small farmers. Thus, this paper proposes to show the stagewise development of the formal Bolivian RFM's, analyze the influence of agricultural and credit policy in the development and performance of these RFM's, and set forth some policy recommendations for directing more credit to the large number of Bolivian small farmers.

Jerry R. Ladman is an associate professor of economics and director of the Center for Latin American Studies, Arizona State University, and Ronald Tinnermeier is an associate professor of economics, Colorado State University.

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The Development of Bolivian Agriculture and RFM's

Prior to the Revolution of 1952, Bolivia had little need for well-developed rural financial markets. Apart from a strong tin-mining industry, the country had progressed little since colonial times. Political instability reigned; little manufacturing existed; and most of the population was Indian, living on large estates in the high mountain plains and valleys as traditional peons or farmers of small plots. Commercial agriculture was not widespread, and the country imported basic food stuffs and exported virtually no agricultural products. After the Revolution the major tin mines were nationalized, and the large landed estates were broken up and parceled out to the campesinos under an extensive land reform program. A major program was launched to develop the sparsely populated tropical plains east of the Andes (Oriente) where petroleum and tropical hard woods were located and fertile soils offered potential for agricultural and livestock activities. Considerable foreign economic and technical assistance poured into the country, especially that of the U.S. Agency for International Development (AID).

The government established major goals of import subsitution of basic food stuffs and higher incomes for the beneficiaries of land reform. Although offices were established within the Ministry of Agriculture for the standard activities of extension, research, etc., these programs had difficulties due to the lack of financial support and trained personnel. Agricultural credit was considered to be a main policy instrument, and the Agricultural Bank of Bolivia (ADB) was the main source. It was not until the 1970s, given the reorganization associated with the land reform and the uncertainty and consequent instability associated with the new leftward leaning government, that the agricultural sector began to

grow rapidly. Growth rates of 2.1%, 3.9%, and 6.7% were observed for 1973, 1974, and 1975, respectively. A number of factors contributed to this growth. Perhaps most important was the military coup of 1971, which established a conservative but progressive-minded government that created an ambiance of political stability. Second, by this time the Oriente flourished under rice, sugar, and livestock production and also entered a favorable cotton export market. Third, the land reform program was consolidated such that many of these farmers were in a position to enter commercial production. Fourth, considerable foreign assistance was directed to the sector—in 1971–73 it accounted for 30% of the agricultural budget (Wennergren and Whitaker).

Agricultural credit facilitated this expansion, and the partial development of more extensive RFM's has been observed since 1967. As shown in table 1 the real value of the annual flows of agricultural credit from the Bolivian banking system grew 4.6 times during 1967–75. In 1967 the ADB accounted for over 90% of this credit, but by 1975 the percentage had fallen to 54, indicating important, absolute, and relative increases by the commercial banks. (In 1975 about 28% of the total agriculture credit was extended by the government's State Commercial Bank and 18% by the several private banks.)

In spite of this impressive increase and structural change there are a number of indicators that Bolivian RFM's were not performing the previously specified major roles well. First, there is little evidence that rural savings are effectively being mobilized, particularly among small farmers. Although Bolivians experienced an eight-fold increase in real savings deposits in banking and nonbanking institutions during 1966–75, most institutions and offices are located in major urban centers and, apart from some relatively minor cases, cater almost exclusively to urban clientele (Ladman, Tinnermeier, and Torrico). Furthermore, the ADB does not have a savings account window. It is expected, however, that medium and large-sized farmers have savings accounts in the cities.

Second, credit was being distributed disproportionately to the Oriente and to medium and large-sized farmers rather than to the campesinos in the high plains and mountain valleys. Almost all private bank credit and 70% of the loan volume under the AID financed rediscount program (FRA-1) went to the Oriente, while three-fourths of the ADB credit during 1964–74 went to the same region (Ladman, Tinnermeier and Torrico).

Third, Bolivian RFM's do not have strong linkages with domestic and foreign financial markets except those that are forced by the Central Bank and foreign aid. Monetary savings are not being extensively generated, and commercial banks tend to steer away from agricultural loans. Agricultural lending would likely be considerably reduced were it not for foreign aid earmarked for that purpose of which most must be used to cover the decapitalization created by the severe delinquency problem experienced by all banks. The average annual delinquency rate for the ADB between 1972 and 1975 was 44.5%. If a number of previously delinquent loans had not been refinanced, the rate would have been even higher (Banco Agrícola de Bolivia

Table 1. Annual Credit Flows to Agricultural Private Sector in Bolivian Banking System, 1967–75 (Millions of 1966 Pesos)

Year	Total Agricultural Credit	Percentage of Total Agricultural Credit		Commercial Bank Agricultural Credit as Percentage of Total Commercial Bank Credit
		Agricultural Bank of Bolivia (ADB)	State and Commercial Banks	
1967	41.6	90.1	9.9	0.8
1968	45.5	74.0	26.0	1.9
1969	79.7	82.8	17.2	2.2
1970	74.1	74.3	25.7	2.9
1971	122.3	43.9	56.1	9.0
1972	178.4	61.0	39.0	5.6
1973	280.3	63.4	36.6	7.6
1974	207.6	66.2	33.8	6.4
1975	192.1	53.7	46.3	7.6

Source: Banco Central de Bolivia and Banco Agrícola de Bolivia 1976.

1977).[1] In the same time period the State Bank and the private banks were experiencing rates of 30% to 50%.[2] In fact, primarily due to delinquency problems, the State Bank decided to withdraw from agricultural credit in 1976.

Credit Policy and Its Effectiveness

As noted previously, prior to 1967 Bolivian agricultural credit policy relied on ADB to finance agriculture. This bank was established in 1942 and in 1954 received its first foreign loan from AID. In the 1960s it was the beneficiary of several other AID, Inter-American Development Bank, and World Bank loans aimed at increasing domestic production of basic food stuffs. Concessional interest rates were also utilized not only by ADB but also by the Central Bank for the commercial bank agricultural loans. The low levels of commercial bank lending suggest the rates were not successful in inducing agricultural lending.

In 1967 the Central Bank established a policy to force the flow of commercial bank credit to agricultural and other productive activities. It required each bank to lend at least 70% of its loan portfolio to productive sectors by 1971. To facilitate this requirement the Central Bank expanded an existing program of special rediscount credit lines for agricultural loans. Foreign aid played an important role through the Special Fund for Economic Development and the FRA-1 and the FRA-2 programs financed by AID in 1967, 1972, and 1975, respectively. Loans refinanced by these special lines accounted for much of the increase in agricultural lending since 1967 in the State Bank, ADB, and private credit. In addition ADB received extensive external financing not only by AID but also by the World Bank, the Inter-American Development Bank, and the Banco do Brazil. How have these policies contributed to the performance of Bolivian RFM's?

Delinquency is perhaps the most threatening problem to the agricultural banking system in Bolivia. Not only does it decapitalize the institutions and increase their reliance on foreign assistance but it also discourages lending to agriculture. The present-day Bolivian problem in many respects is due to crop failures and unfavorable prices reflecting the lack of supportive infrastructure, appropriate technology, and an adequate marketing system. Another major reason is the lack of absorptive capacity by the credit institutions to appropriately administer the large volumes of new agricultural loans under the special lines of credit. It is little wonder that the State Bank experienced so many loan failures when that institution did not have adequate professional staff to properly analyze and supervise credit.

Bolivia also suffers from a nonrepayment mentality. Bankers and borrowers alike accept the slightest pretext for farmers not repaying. Unfavorable natural conditions and poorly designed loans feed this attitude. Historically, loans have often been made, especially to larger farmers, on a political basis. In many such cases the borrower has almost assumed he had the right not to repay because he knew that legal pressure would not be brought against him. In recent years this has been especially prevalent in the Oriente for cotton and soybean loans, which account for a very significant portion of the delinquent portfolio. A factor that accentuates this practice is the concessional interest rate policy, which encourages borrowers to seek credit for ostensibly agricultural purposes but which in fact is directed to other activities or investments (agricultural illusion). This situation is exacerbated when, due to high rates of inflation such as Bolivia experienced in 1972 through 1974, the real rate of interest is in fact negative and results in an income transfer to borrowers. Clearly, policy has not mitigated but rather worsened the repayment problem.

Bolivia has few policy instruments designed to mobilize rural savings. The ADB does not have a savings window, and most commercial banking is confined to urban centers. Most cooperatives have not been successful in generating savings, and credit unions are only beginning to move into rural areas. Our case studies show that small farmers hold cash reserves and also have relatively liquid investments in livestock. Few, however, know anything of formal savings institutions. The Central Bank has had a minimum nominal interest rate policy on commercial bank time deposits of about 10% over the last ten years. Given inflation and the opportunity cost of money it might be argued this rate is too low; however, the recent large increase in savings in the

[1] Delinquency rates are computed as percentage of outstanding loan portfolio at the end of the year.

[2] For example, during 1972–75 the percentage of loans repaid under the special credit line program (FRA-1) were 20%, 35%, and 43% for the ADB, the State Bank, and the private commercial banks, respectively.

urban centers suggests that other factors are also important. In rural areas an important factor is the lack of an institutional structure to encourage savings.

The Bolivian government in its efforts to reduce agricultural imports and to take advantage of the favorable world cotton market made the conscious decision to direct the bulk of credit to the Oriente region. No doubt they reasoned this was the most rapid and least-cost way of obtaining additional output. If the RFM's were functioning correctly, this would mean resource productivities were higher in this region. Data are not available to measure this. Nevertheless, it does appear that existing governmental policy has created some inequities in the system. Certainly concessional rates of interest, especially in periods of high inflation, have biased credit towards capital-intensive investments leading to regional and on-farm misallocation of resources. Furthermore, these rates encourage agricultural illusion, which leads to intersectoral and regional misallocations. It is widely believed that many of the cotton and soybean loans in the Oriente went for other purposes including foreign investment.

The import substitution and export policies also exacerbated the regional distributional disparities, since the activities supported by these policies are heavily concentrated in the Oriente. This is a somewhat paradoxical result for Bolivian agriculture and illustrates conflicts among policy goals, since credit was not directed in the main to the beneficiaries of land reform.

There has been considerable rhetoric about financing campesinos, but the evidence shows, both in terms of numbers and volumes of loans, that most credit has gone to medium and large-sized farmers, much of it in the Oriente but also to these same select groups in the mountain valleys. The bulk of the small farmers who live in the altiplano and mountain valley regions were untouched. Nevertheless, it is now recognized that, for the long-run interest of social and economic development, credit and other resources must be directed toward this large mass of farmers. To this end Bolivia with AID's encouragement and funding developed two small farmer credit programs in 1974. One, FRA-2, was for a special line of credit to be rediscounted to the commercial banks and ADB for loans to small farmers. The second was a small farmer supervised credit program administered by ADB. In 1975, AID funded a program to develop credit cooperatives among small farmers. At this point the programs appear to have been relatively successful in providing credit to these farmers. Delinquency has not been a major problem to date. They would appear, however, to result in high transactions costs for both farmers and banks.

Several policies were established to force linkages between RFM's and other financial markets. Foreign aid has been effectively tapped; during 1966–76 foreign donors committed over $92 million for agricultural credit (Ladman, Tinnermeier and Torrico). Special credit lines utilize not only foreign aid but also government revenues. In addition, commercial banks must employ part of their own capital in financing these loans. Without these interventions it is very unlikely that many funds would have flowed to agriculture through the banking system. On the other hand, concessional interest rate policy has inhibited the flow of funds to agriculture. The low rates charged by ADB and the commercial banks relative to their borrowing costs on the open market leave little margin to cover operating costs and risk and to provide for capital growth. There have been no policies directly aimed at mobilizing rural savings.

Conclusions and Policy Recommendations

Although it is easy, as we have done, to point out the failures and problems of rural financial markets and credit policy in Bolivia, the country should be commended for the progress that it has made in financing agriculture given that only twenty-five years ago the country was considered to be one of the most traditional and less developed countries in the world and one with little development of financial markets, much less RFM's. Considering the major steps that were required to try to overcome the institutional structure that inhibited growth, the lack of human capital and expertise in agriculture, and the political instability, it is somewhat remarkable that the RFM's have progressed to their present level. It is clear that this progress would not have been attained without massive foreign assistance. Nevertheless, as noted previously, many of the policies employed gave rise to undesirable results. It appears that Bolivia has crossed the first stage of establishing the rudiments of an RFM and now needs to concentrate on the

second stage of consolidating, correcting for past policy errors, and adding to the RFM structure. On the basis of the findings in this paper, the following policy elements seem to be called for during the second stage.

(*a*) The concessional interest rate policy should be revised in order to increase returns to lenders and thus stimulate their lending to agriculture, reduce agricultural illusion and raise the social marginal productivity of credit, stimulate the linkages between RFM's and other financial markets, and reduce the delinquency problem.

(*b*) An appropriate deposit rate and institutional structures should be established that will mobilize rural savings in order to increase the supply of loanable funds.

(*c*) More attention should be placed on small farmer credit programs with special emphasis on the capacity of existing and alternative institutional forms of the country to serve their credit needs.

(*d*) The absorptive capacity of lending institutions must be increased. This has three dimensions: upgrading and training of bank personnel not only in matters directly related to agricultural credit but also to bank management, the development of more efficient credit delivery systems within the existing institutions, and experimentation with alternative institutions such as cooperatives and credit unions.

(*e*) Immediate attention must be focused on the serious loan repayment problem and its solution. The current delinquency rates directly affect the financial viability of both the lenders and borrowers and must be significantly reduced for the RFM's to function effectively.

(*f*) An appropriate set of policies should be developed that support or condition the overall functioning of RFM's but that are not sufficiently discussed in this paper, including policies in the areas of marketing, prices, trade, infrastructural development, technology development, and dissemination among others.

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Some Current Aspects of Agricultural Finance and Banking in the United States

Emanuel Melichar

For the past twenty years or so, farm credit markets and mechanisms in the United States have been recommended to others as models worthy of emulation. Analysts commenting on overall current developments have generally concluded that "credit-worthy" operators of commercially viable farms could obtain "adequate" financing at "reasonable" rates and other terms. It is true that many specific aspects of the system were continually being questioned and reexamined—whether groups such as expanding farmers, beginning farmers, or marginal operators were obtaining economically or socially desirable amounts or terms of credit; whether optimum terms were being used for machinery and other types of loans; and whether certain lenders such as small rural banks could cope with increasing individual and/or total farm loan demands (Melichar 1975). But these concerns represented "fine-tuning" of a system with which most borrowers, lenders, and analysts were generally pleased (Brake and Melichar).

In discussing the successful performance of U.S. farm credit markets, analysts generally emphasize the diversity of lenders meeting various farm loan demands and the suitability of lending terms and techniques. Another integral aspect, however, is the very favorable farm loan repayment record that has generally prevailed since the beginning of World War II and which certainly underlies the heralded responsiveness of lenders to farm loan demands. The lack of severe farm loan repayment problems in the 1950s, during what was regarded as a postboom era, made a profound impression on lenders and on research workers in farm finance. This favorable experience led them first to accept greater relative use of debt financing and in short order to actively encourage more highly leveraged financial positions as a means of increasing the growth rate of the income and wealth of individual farmers. This paper examines the possibility that the coincidence of these attitudes with the boom in farm capital expenditures and land prices that began in 1972 may culminate in the reappearance of problems that U.S. farm credit markets have not faced for nearly four decades.

In its 200 year history, U.S. agriculture has experienced a number of boom-bust sequences that dominate its financial history. Jones and Durand note that four major farm investment and land-price booms preceded World War II, with each followed by about two decades of severe farm mortgage debt distress. The boom of World War I was triggered when operators' real net farm income jumped by 48% between 1916 and 1917. In spite of subsequent annual declines that by 1920 had pushed such income below its 1916 level, capital expenditures and land prices rose substantially until 1920. The boom ended when farm income virtually collapsed in 1921 and remained relatively depressed during that decade. The national index of farm land prices fell during each year of the 1920s, registering a total decline of 33% by 1929. The effect on farm lenders was correspondingly grave. For example, nearly 6,000 commercial banks failed during the period 1920–29, most of them in rural states. As is well known, the onset of the Great Depression further aggravated these farm financial difficulties.

After this period of financial adversity, the farming sector experienced another boom during 1941–52. This boom was followed by widespread financial problems that were characterized as a "cost-price squeeze" but not by general debt-repayment distress. The primary

Emanuel Melichar is a senior economist in the Division of Research and Statistics, Board of Governors of the Federal Reserve System, Washington, D.C.

The analyses and conclusions presented are solely those of the author and do not necessarily reflect the views of the Board of Governors or of other members of its staff.

new factor thought responsible for this result was the government price support program for major crops, which limited the decline in net farm income. Financial innovations such as amortization and longer maturities of farm mortgage loans, federal insurance of bank deposits, and federal lending programs were also considered to have been helpful.

Yet another boom began in 1972. With the aforementioned programs and arrangements still in place, most farm credit market participants and analysts appear to have implicitly adopted a sanguine view of the postboom future, in which experience more adverse than that of the 1950s is regarded as improbable. A hallmark of this view is that farm land prices are not likely to fall significantly, if at all. Apparently, any postboom financial distress is expected to be mild or of short duration.

This view may be, in part, still another legacy of the experience of the 1950s; thus, it may be useful to take note of the many differences between the financial situation then and now. First, however, some major uncertainties should also be noted. For instance, at the end of the earlier boom it turned out that farm land prices were consistent, on average, with the level at which the federal government was initially willing to support the prices of major crops. The postboom fall in the national index of land prices was limited to a slight decline in a single year, 1953. The degree of compatibility directly after this boom remains to be revealed. Recall, also, that analysts in the 1960s agreed that the combination of decreasing unit costs of production and stable, supported output prices was the chief factor responsible for the upward trend in land prices after 1953 (Brake and Melichar, p. 442). A high rate of technological advance and relatively stable prices of inputs such as fertilizer and fuel contributed much to the steady reduction of unit costs. At present, the near-term return of such favorable trends seems doubtful.

In addition to these uncertainties, there are several major differences between the current financial situation and that of the early 1950s. The boom that followed World War II was unique in that, for a number of reasons, it did not develop the financial excesses present in earlier booms and perhaps in the current one as well. First, the period of relatively favorable real farm income that fueled the boom was of extraordinary length. Operators' real net farm income rose by 79% between 1940 and 1942, maintained that level for seven years (1942–48), and then held at a level only about a fourth lower for another four years (1949–52). Operators' real net farm income rose by 103% between 1971 and 1973 to trigger the current boom, but, in sharp contrast, it has since fallen significantly in each succeeding year and by 1976 was back at approximately the 1971 level (Melichar and Sayre 1976).

Because of the longer period of relatively high income and also because machinery and construction materials were relatively scarce during the first half of the earlier boom, farmers' liquid financial assets (currency, bank deposits, and U.S. savings bonds) had by the end of the boom risen to a level of 8.5% of total assets, more than twice the present level of 3.5% (Melichar and Sayre 1976). Rural commercial banks were also very liquid at the end of the previous boom, in contrast to their present tight situation, which will be detailed later.

Finally, and perhaps most importantly, debt played a limited role in financing the earlier boom. To begin with, total outstanding debt declined through 1945. Outstanding debt then doubled between 1946 and 1953, but the absolute increase was small compared with the large capital flows of that period. In this respect, the earlier experience was a highly untypical boom.

It is characteristic of most booms that euphoric projections of future income streams are widely accepted by participants, both borrowers and lenders. But during and immediately after World War II, most participants expected a rapid retreat to prewar levels of commodity prices and income. In addition, they (and farm finance analysts as well) were highly cautious toward use of debt as a result of the disastrous experience of preceding decades. These expectations and attitudes inhibited both capital spending and the development of highly leveraged financial positions. In the postboom era of the 1950s, therefore, there were comparatively few financial excesses to unwind. The farming sector entered the period with relatively large credit reserves—especially after the level of land prices proved sustainable—and with a major lender group, the rural commercial banks, in a good position to accommodate loan renewals and new loan demands.

The current boom and its financing present significant contrasts with this earlier experience, which may be explored with the aid of tables 1 and 2. A sharp increase in each of the

Table 1. Capital, Credit, and Income Flows (Annual Average, Billions of Dollars)

Item	1950–54	1955–59	1960–64	1965–69	1970–71	1972	1973–75
Capital flow	7.6	7.2	8.6	11.9	13.6	18.6	24.6
Real estate purchases	2.3	2.8	3.3	4.4	5.0	8.5	10.3
Capital formation	5.3	4.4	5.3	7.5	8.6	10.1	14.3
Machinery	3.1	2.8	3.2	4.6	4.9	5.7	8.3
Livestock	0.5	0.1	0.3	0.1	0.6	0.4	0.4
Stored crops	0.1	0.2	—	0.3	0.1	0.4	1.2
Financial assets	0.1	−0.1	—	0.4	0.6	1.2	0.7
Buildings	1.5	1.4	1.8	2.2	2.4	2.4	3.7
Financing of capital flow	7.6	7.2	8.6	11.9	13.6	18.6	24.6
Debt (net increase in debt)	0.9	1.6	2.3	3.0	3.3	6.7	9.0
Internal	6.6	5.6	6.2	8.9	10.4	11.9	15.6
Cash flow	18.5	16.5	17.6	20.9	23.6	30.0	44.3
Addenda							
Capital consumption	3.2	3.9	4.6	5.8	7.1	7.9	10.7
Flows excluding capital consumption							
Net capital flow	4.4	3.3	4.0	6.1	6.5	10.7	13.9
Net capital formation	2.1	0.5	0.7	1.7	1.5	2.2	3.6
Net income	15.3	12.6	13.0	15.1	16.5	22.2	33.6
Net internal financing	3.4	1.7	1.6	3.1	3.3	4.0	4.3

Sources: Melichar and Sayre 1976. Earlier articles by the author define and discuss each series (Melichar 1971, 1973).

major components of capital flow occurred during 1972 and 1973 (table 1). Levels reached in 1973 were roughly maintained through 1974 and 1975. Farm cash flow (gross income minus production expenses other than capital consumption) also rose through 1973 and then leveled out. In tables 1 and 2, the first six years of this decade are split into three periods that reflect this overall pattern.

Capital flows are financed either through

Table 2. Relationships among Capital, Credit, and Income Flows (Annual Average, Percentage)

Analytical Ratio	1950–54	1955–59	1960–64	1965–69	1970–71	1972	1973–75
A. Relative burden of capital flows							
Capital flow/cash flow	41	44	49	57	58	62	55
Real estate purchases/cash flow	12	17	19	21	21	28	23
Capital formation/cash flow	29	27	30	36	36	34	32
Net capital flow/net income	29	26	31	40	39	48	41
Real estate purchases/net income	15	22	25	29	30	38	31
Net capital formation/net income	14	4	5	11	9	10	11
B. Relative allocation of income flows to financing of capital flows							
Internal financing/cash flow	36	34	35	42	44	40	35
Net internal financing/net income	22	13	12	21	20	18	13
C. Relative repayment burden presented by debt financing							
Debt financing/cash flow	5	10	13	14	14	22	20
Debt financing/net income	6	13	18	20	20	30	27
D. Relative role of debt in financing of capital flows							
Debt financing/capital flow	12	23	27	25	24	36	37
Debt financing/capital formation	17	36	43	40	38	66	63
Debt financing/net capital flow	20	48	58	49	51	62	66
Debt financing/net capital formation	43	320	329	176	220	305	250

borrowing, measured by the net increase in outstanding debt, or from internal resources (calculated residually as capital flow less the increase in debt). Internal financing continues to be the major source of funds, but debt financing has increased sharply. In studying capital flows and their financing from internal and external sources, Tostlebe found it useful to observe the behavior and level of several ratios that express meaningful relationships among these series. Four categories of such ratios are presented in table 2, each responsive to a specific analytical question.[1] The ratios in part A of table 2 indicate the relative burden that the capital flow imposes on the cash flow of the farming sector (cash flow is also used for consumption and nonfarm investment). The relative burden increased significantly during the early and mid-1960s but has not risen since above the levels reached in 1965–67—a pattern that reflects the behavior of its capital formation component.

Part B shows the proportion of cash flow allocated to financing of capital flow. Surprisingly, in view of the huge cash flow of 1973, the proportion of cash flow allocated to internal financing both then and in the next two years was no higher than in the 1950s and early 1960s and lower than in the five years preceding 1973. Ratios in part C represent an attempt to derive an indication of the relative debt repayment burden presented by ongoing increases in debt. These indicators reached new high levels after 1971. Cash flow will have to rise in the future to keep this indicated increase in relative repayment burden from materializing. If, as in the 1950s, cash flow fails to rise, repayment of past borrowings is more likely to be burdensome.

It is evident that the farming sector has in recent years allocated less of its income stream to financing of capital flows and that it has employed increased debt financing relative to that income stream. In the 1950s such a shift occurred under the pressure of falling income, but in 1973 and 1974 a further shift occurred in the face of relatively high aggregate cash flow and income. One explanation is that these aggregate series may reflect a concentration of increased debt among a relatively small proportion of farmers, primarily among those who significantly expanded their operations. If future income should fail to meet their expectations, financial "excesses" may be revealed among this group.

Ratios in part D of table 2 simply show the percentage of capital flow or capital formation that can be regarded as financed by the increase in debt. The relative role of debt in financing capital formation during 1972–75 (64%) is the highest since that found by Tostlebe for 1915–19 (76%) and in particular far exceeds that during even the final stage of the last boom (28% in 1950–52).

In short, the current capital spending and land price boom has been debt financed to an extent not experienced since 1920. Thus, some apprehension about the near-term finances of the farming sector appears justified. Research and policy attention to means of dealing with financial stress seems in order.

All major lender groups have participated in financing the boom, but some have been more active than others and have increased their share of total outstanding farm debt. The cooperative farm credit system increased its share from 23% in 1970 to 31% in 1977, and over the same period the share held by commercial banks rose from 28% to 30%.

Each of these two groups has certain advantages and disadvantages, vis-à-vis the other, with respect to ability to cope with a period of financial distress in agriculture. For instance, the cooperative system, in contrast to most banks, has all of its loans in agriculture, but they are nationally diversified, whereas the loans of most banks are concentrated in a small region. Banks' sources of funds, consisting at rural banks mostly of local deposits, may suffer with reductions in farm income, while the cooperative system's sources would be largely unaffected by that event. On the other hand, extensive farm loan problems would eventually affect the cooperative system's ability to raise funds and would also increase their cost, whereas, with their deposit insurance and their more diversified portfolio, the supply of funds at many banks might be relatively unaffected by similar farm loan experience.

After considering such factors, it appears that the lending institution most vulnerable in the event of adverse farm loan experience is the small rural bank that is heavily involved in

[1] The ratios shown on a "net" basis represent an alternative but parallel approach, in which capital consumption (depreciation allowances and accidental damage) has been subtracted both from cash flow and from the capital formation component of capital flow (see the addenda to table 1). This approach implicitly assumes that the funds designated in the national accounts as capital consumption allowances are used to pay for an equal amount of capital expenditures. Thus, one focuses on net capital formation and net capital flow and examines how these flows are financed from net income and the net increase in debt.

Table 3. Insured Commercial Banks by Relative Involvement in Farm Lending, 31 December 1976

Item	All Banks	Farm Loans as Percentage of Total Loans at Bank: Under 5	5–24	25–49	50+
Banks					
Number	14,397	5,650	3,760	2,874	2,113
Percentage of total	100	39	26	20	15
Farm loans					
Billions of dollars	30	4	9	9	8
Percentage of total	100	14	30	30	26
Average per bank (million $)	2.1	0.7	2.4	3.1	3.6
As percentage of total loans	6	1	12	35	64
Total loans as percentage of					
Assets	53	53	54	54	54
Deposits	65	66	62	60	60
Deposits					
Billions of dollars	825	635	127	43	20
Percentage of total	100	77	15	5	2
Average per bank (million $)	57	112	34	15	9
Capital and surplus per bank (million $)	5.4	10.7	2.9	1.3	0.9

farm lending and at which farm income trends significantly affect deposit growth. Data in table 3 indicate that perhaps one-third of all commercial banks are currently in this category (last two columns of the table) and that such banks account for over one-half of all farm loans at commercial banks.

The most vulnerable group isolated in table 3, in the last column, is that comprised of the 2,100 banks with more than half (an average of 64%) of their loans in farming. While 15% of the nation's banks are in this group, and it accounts for 26% of all farm loans outstanding at banks, these generally small institutions hold only $20 billion, or 2.4%, of the nation's bank deposits. This sum is less than the deposits at each of the nation's three largest banks. Obviously, should adverse farm financial experience develop, it may prove desirable or necessary to give this group of banks attention and assistance very disproportionate to its relative importance in the nation's banking system and financial markets.

Given the inherently risky situation faced by these undiversified banks, it is disturbing to find in table 4 that their relative liquidity has very recently been drastically reduced, on average, from that maintained since the late 1960s. This development has resulted from the adverse impact of falling farm income on deposit growth and on loan repayment, as well as from new farm loan demands resulting both from falling income and from the need to finance increased stocks of grain (Melichar 1977). These trends are continuing as of mid-1977 (Melichar and Sayre 1977). Clearly, if the farming sector is now entering a postboom period, the small rural banks are in a far different situation than the one characterized by their highly liquid positions of the early 1950s. Again, research and policy attention might

Table 4. Average Loan/Deposit Ratios at Insured Commercial Banks by Relative Involvement in Farm Lending (%)

31 December	All Banks	Farm Loans as Percentage of Total Loans at Bank: Under 5	5–24	25–49	50+
1960	52	53	52	44	43
1961	51	52	51	43	43
1962	54	55	53	45	45
1963	58	59	57	47	47
1964	58	60	55	48	48
1965	61	63	56	50	49
1966	62	64	60	52	52
1967	60	61	56	52	53
1968	61	62	57	52	51
1969	66	68	60	53	53
1970	62	63	58	53	56
1971	61	62	58	53	54
1972	63	65	59	53	52
1973	67	70	61	55	52
1974	68	70	61	56	53
1975	64	66	60	57	55
1976	65	66	62	60	60

well be directed to the potential financial stress and its amelioration.

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Interest Rate Restrictions and Income Distribution

Claudio Gonzalez-Vega

Credit has been one of the most important components of the strategies for development in the agricultural sector of low income countries (LIC's). Not only is the input provided—money—fungible but an infrastructure, the banking system, is available for its supply, and it can be administered at a significant distance from the farm, unlike other inputs. Because credit programs are easier to implement than another type of program, there has been a rapid expansion of the volume of agricultural credit granted by formal lenders in LIC's.

Two important and universal features of this expansion have been the the concentration of the loaned funds to a select clientele and the low rates of interest charged. Only a small fraction of the farmers of LIC's receive formal credit—about 5% in Africa and 15% in Asia and Latin America (Donald, IBRD). This concentration is also reflected in the distribution by size of the loans granted. Consider Honduras, an intermediate case in Latin America, where in rural areas the outstanding credit per capita is $35, but only 10% of the rural families have bank loans. Out of every ten families, nine receive no formal loans and one receives a loan of $2,100. Moreover, among those obtaining credit, 9% receive about 81% of the total money loaned.

The rates of interest have been low because they have been maintained at about the same rates as those charged in countries rich in capital and have not reflected the opportunity cost of capital or its shadow price in LIC's. Also, the supply and demand for formal loans have not been equated, and this has generated excess demand, which has required nonprice rationing. Bank interest rates have been lower than those charged by informal lenders, and they have frequently failed to cover the cost of granting credit. In particular, because they do not cover the cost of entering into additional markets, the low rates have prevented formal lenders from serving marginal clients, making it necessary to subsidize financial institutions—for their survival. Also, low interest rates have transferred a substantial subsidy to privileged borrowers. Finally, they have implied ceilings on the deposit rates paid on savings, and in inflationary LIC's, they have been negative and unpredictable in real terms. Interest rates have not been low because of market forces, higher productivity, or financial innovation; rather, they have been imposed by usury laws and central bank regulations. These administered rates have been kept fixed at low levels despite changing circumstances, but their rigidity has not prevented the real rates from affecting allocative efficiency, institutional viability, growth, employment, equity, and income distribution in the rural areas of LIC's. This paper examines their impact on the latter.

Any farmer's net income is a function of his internal productive opportunity and other investment options as well as his command over the resources necessary to take advantage of them. The farmer's control over resources depends in turn on his own endowments and on his access to external finance. In fragmented markets, these opportunities, endowments, and access to finance are poorly correlated. Many farmers, each with his own unique set of endowments and opportunities, are so isolated that they earn a wide range of rates of return (McKinnon). These farmers face very different income growth potentials, which are reflected in the distribution of income.

The impact of access to external finance on income distribution can be illustrated by referring to three financial regimes. First, consider a group of farmers under conditions of self-finance. Each will be able to exploit his opportunities only to the extent allowed by his endowment. Farmers with larger endowments will earn higher incomes. However, the value of the marginal product of the inputs used will

Claudio Gonzalez-Vega is a professor of economics, University of Costa Rica, San Jose.

be higher, *ceteris paribus,* when the farmer's own endowment is small and his productive opportunity is good. Even though the large farmers may use superior production techniques and have larger endowments, if their endowments are better than their opportunities, given the cumulative biases of income growth processes and of diminishing returns, the value of the marginal product of the inputs employed may be lower for them than for the small farmers.

In the previous case, if direct external finance—the transfer of resources via loans from large to small farmers—is possible, the net incomes of both classes of farmers will increase. Moreover, if the value of the marginal product of the inputs declines faster for the small farmers than for the large farmer, in view of the relatively limited entrepreneurial ability and small endowment of other fixed inputs of the former, the absolute and relative net gain in income as a result of the loan will be greater for the small farmer than for the large. Thus, in addition to its allocative effect, direct external finance improves income distribution (Gonzalez-Vega).

A similarly favorable distributive impact takes place under a regime of indirect external finance, when credit is granted by an institution that also collects savings. Consider two farmers with identical production opportunities. Under the conditions of self-finance, if their endowments are equal, their incomes are equal, but if not, the farmer with the larger endowment earns a higher income. However, if both farmers have access to credit, their incomes are equalized. Therefore, the extent to which differences in income are due to differences in endowments is reduced by access to credit. This distributive property of access to credit is also present in a dynamic situation where opportunities can be improved through technical change. In sum, the more fragmented the capital markets are, the more diverse their individual participants will be; and the more dynamic and risky the available opportunities are, the more crucial access to credit will be in determining income growth potentials and income distribution.

Financial intermediation is not free, however. The costs are social because the resources used for credit could have been devoted to increasing output elsewhere. The costs are private as well because lenders have to compete for the resources in the market. On the other hand, credit is not a homogeneous product. There are many dimensions of credit: short term and long term, agricultural and industrial, large and small borrowers. Each one of these dimensions is a separate product with its own peculiar cost function.

Once the various dimensions of credit and their costs are distinguished, it is clear that the socially optimum, competitive rates of interest, will not be the same for all farmers. A social optimum requires that each farmer be granted a loan of a size that makes the marginal cost of lending equal to the value of the marginal product of the inputs purchased with it and, in turn, to the rate of interest charged. If a larger loan is granted, more resources are spent in administering it than are generated by the additional production induced, with a net loss to the society. Therefore, the optimum rates of interest will be higher, *ceteris paribus,* the better the productive opportunity, the smaller the endowment and the higher the marginal cost of lending to a given farmer are.

Similarly, a profit-maximizing lender in a monopolistically competitive market will try to segment it on the basis of demand elasticities or of marginal costs in order to charge different rates to different borrowers. If more inelastic demands and higher costs are associated with small farmers, the rates charged to them will be higher.

If restrictions are imposed on rates of interest, lenders may practice credit rationing, i.e., granting smaller loans than those demanded at the rate charged. From the point of view of the individual borrower, rationing implies an excess demand for credit at the rate of interest paid (Jaffee, Eckaus). Generally, a lender restricts the size of a loan if the marginal cost of granting it is higher than the imposed rate of interest. If a larger loan is granted, the added costs would be greater than the revenues and his expected profits would decline. Since marginal cost is an increasing function of the size of any individual loan (Gonzalez-Vega), the lender can reduce his marginal cost and equate it to the level of the imposed rate by reducing the size of the loan. If this rate becomes sufficiently low, dropping below the average variable cost, rationing takes the form of exclusion from the lender's portfolio.

The possibility that a borrower will be rationed depends on the relationship between the marginal cost and the demand functions faced by the lender and on the nature of the restrictions. The slower the marginal cost rises as the size of loan increases, a function of risk, and the faster the quantity of credit demanded increases as the rate of interest declines due to

the behavior of the value of the marginal product of the inputs, the less likely is rationing. The low ceilings imposed on rates of interest for loans in LIC's have led to widespread rationing, as evidenced by quotas, long delays in disbursement, and other quantitative restrictions. While the loans received by most farmers have been smaller than those demanded at the low rates, a few privileged borrowers have obtained all the credit they have demanded at the restricted rates. Although this preferential treatment reflects the influence of social and political power, the result can also be explained by purely economic considerations related to the profit-maximizing behavior of private lenders and to the survival behavior of public lenders.

Furthermore, given empirically relevant values of certain parameters, when the ceilings imposed on interest rates become more restrictive—due to inflation, increased lending costs, or the frequent practice of granting preferential rates for specific activities—the size of the loans granted to nonrationed borrowers increases and to rationed borrowers decreases. This is the "iron law of interest rate restrictions" (Gonzalez-Vega). As the ceiling becomes lower, nonrationed borrowers move along their demand curves, demanding and receiving larger amounts of credit at the lower rate. On the other hand, rationed borrowers move along the lender's marginal cost curves of granting credit to them, and the lender grants them even smaller loans than before, although they, too, demand larger loans at the low rate.

Small farmers are rationed credit long before the larger ones because the costs of lending per unit loaned are inversely related to the size of loan. The iron law of interest rate restrictions implies that the size of loans granted to large farmers increases and the size of loans granted to small farmers decreases as interest ceilings become more restrictive. This, in turn, leads to a reduction in both the absolute and relative shares of credit small farmers receive from formal lenders; that is, the ceilings redistribute the credit portfolios in favor of large farmers, contributing to the concentration of income in the rural areas of LIC's. Moreover, given the high cost of lending to rural clients, the ceilings usually exclude the majority of the small farmers in LIC's from access to formal credit. It is these excluded farmers—the smallest and the poorest—who suffer the most significant loss as a consequence of the ceilings.

Subsidized interest rates are frequently recommended as the only mechanism for effecting income transfers to small farmers that is politically feasible or administratively possible. Unfortunately, credit in general and subsidized interest rates in particular are very inefficient for income redistribution. Subsidized rates affect income growth potentials through their effect on the access to resources that different classes of farmers have and have a direct effect on income distribution. The grant transferred is directly proportional to the size of the loan. The larger the loan, the greater the unrequited transfer. Since loan size and borrower size are positively correlated, the amount of the grant becomes a direct function of the borrower's wealth. The large borrowers receive large subsidies, while the small borrowers who constitute the target of the strategy receive, at best, small loans with their implicit subsidy. Nonborrowers—the smallest and the poorest farmers—receive no subsidy at all. This necessarily makes income distribution worse.

Interest-rate ceilings have affected not only the distribution of agricultural loan portfolios: they have also influenced the total value of these portfolios. Through their impact on the rates of deposit, they have reduced the total volume of savings mobilized by the formal financial markets (Shaw). Also, through their impact on the profitability of lending to agriculture, they have reduced the share of the agricultural sector in credit volume. They have also reduced technical efficiency in lending and have sometimes even induced a reduction in the volume of informal credit.

On the other hand, low interest rates cannot eliminate the monopoly of money lenders in the rural areas of LIC's, since they restrict access to formal credit. Low interest rates cannot create the missing physical inputs, the missing markets, or the missing technologies that keep the productivity of farmers low in many LIC's. At a sufficiently subsidized rate, credit could in such cases make an investment opportunity appear profitable to the few privileged borrowers receiving the underpriced resources, but it will not make it more profitable socially. Once the inputs, markets, and technologies are available, subsidized credit cannot stimulate adoption of the innovations unless large enough loans are granted to large numbers of farmers. Subsidized rates, however, lead to rationing and exclusion. Access to formal credit can do a better job even at fairly high rates of interest as long as these

rates are lower than those charged by informal lenders.

Therefore, except in a few cases that are empirically unimportant, the arguments for low interest rates are invalid. The important thing is access to credit. The policies that have attempted to keep the price of credit low have modified access in undesirable ways. As a result, these policies have not only reduced both the allocative efficiency and the viability of financial institutions but they have also contributed to concentration of income within the rural areas of low income countries.

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The Role of Risk Transfer Institutions in Commodity Policy (Gary L. Seevers, Commodity Futures Trading Commission, Chairperson)

Commodity Futures Exchanges and the North-South Dialogue

Mark J. Powers and Paula Tosini

During the last decade increased attention has been given to the role commodity futures exchanges might play in international commodity policy. There have been suggestions (McKinnon, Houthakker) that national and international agencies, whose goal is the stabilization of commodity prices, should find it less costly to intervene in futures rather than spot markets. Recently, several less developed countries (LDC's) have requested assistance from the industrialized nations in increasing access to commodity exchanges located in developed areas (Conference on International Economic Cooperation). Many developing countries have also asked for help in establishing futures markets in their own countries (U.N. Committee on Trade and Development 1977).

The purpose of this paper is threefold: (*a*) to report on LDC's participation in U.S. markets and discuss related public policy issues, (*b*) to explore the positive externalities that might be generated in LDC's that establish their own futures markets, and (*c*) to identify certain issues related to the role of futures markets in international commodity agreements. Although this latter topic is only peripherally related to the first two subjects, it is important because, at the same time we are seeing a growing interest by LDC's in using futures markets, we are also faced with proposals for international commodity agreements that combine governmental activity in futures and cash markets.

Mark J. Powers is chief economist and Paula Tosini is an economist with the Commodity Futures Trading Commission, Washington, D.C.

Developing Countries and Commodity Markets

Futures markets for primary products provide several potential benefits for developing countries—risk transfer, a system of forward pricing, improved market information, reduced search costs, alternative buyers and sellers, and development of the local financial infrastructure of the country in which the exchange is located. Alternative buyers and sellers (in the form of speculators) give the pricing process greater visibility and liquidity and should be particularly important in monopsonistic markets that many producers within developing countries face (U.N. Committee on Trade and Development 1976). Futures trading might also encourage the development of forward supply contracts using the futures price (taken as a given by both parties) as the index for transfer pricing.

Further, to the extent that exchange pricing integrates the LDC's markets into world markets, the price elasticity of the exchange-traded commodities should increase. For example, if palm or coconut oil were traded on futures exchanges, then to the extent that this causes their prices to move more closely with those of other fats and oils, one should expect a rise in the market elasticities of the individual oils. With the exception of the development of the local financial infrastructure, these benefits of futures trading should accrue to primary producing countries regardless of the location of the exchange.

Three issues concerning LDC's and commodity markets are examined below: the accessibility of U.S. markets to foreigners, the nature of the positive externalities generated

Table 1. Average Number of Traders per Month-End Date, 30 June 1976–28 February 1977

Country Group[a]	Grains and the Soybean Complex	Livestock and Meat	Foodstuff Domestic[b]	Foodstuff Foreign[c]	Financial Instruments[d]	Industrial Goods[e]	Precious Metals[f]
A	131	29	15	67	12	84	68
A-1	108	29	15	65	11	80	67
A-2	23	—	[g]	2	[g]	4	1
B	3	—	—	3	1	1	3
C	21	[g]	1	13	2	9	5
D	4	1	1	5	1	4	5
E	6	4	[g]	2	—	13	21
E-1	1	—	—	—	—	2	—
E-2	5	4	[g]	2	—	11	21
F	[g]	—	—	1	—	1	[g]
All countries	164	35	18	91	16	128	102

Source: CFTC series '01 reports (see fn. 1).

[a] A = Canada and Australia, West European countries; A-1 = Australia, Canada, Belgium, Denmark, Great Britain, France, West Germany, Holland, Italy, Leichtenstein, Netherlands, Switzerland, and Sweden; A-2 = Austria, Ireland, Finland, Greece, Malta, Norway, Portugal, and Spain; B = Bermuda, Bahamas, Cayman Islands, Jamaica, British Virgin Islands, and West Indies; C = Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Paraguay, Panama, Uruguay, Venezuela, and Botswana, Africa; D = Mid-East: Iran, Israel, Kuwait, Lebanon, Saudi Arabia, Sudan, UAR, and the Trucial States; E = Far East and Pacific; E-1 = Japan; E-2 = Communist China, South Korea, Indonesia, British Solomon Islands, Malaysia, Philippines, Singapore, Taiwan, and Hong Kong; and F = South Africa.

[b] Potatoes, eggs, and orange juice.

[c] Coffee, cocoa, and sugar.

[d] GNMA's, T-bills, and foreign currencies.

[e] Rubber, cotton, lumber, plywood, copper, palladium, and petroleum.

[f] Gold, silver, platinum, and silver coins.

[g] Average less than 0.5.

by commodity exchanges, and the prerequisites for the establishment of such exchanges in developing countries.

Foreign Participation in U.S. Markets

The extent of current foreign participation in U.S. futures markets can be deduced from data on foreign traders' activities for the nine month-end dates from June 1976 through February 1977. Although this information covers only the large foreign traders, it is believed to be a good indication of overall foreign participation in U.S. markets.[1]

The data in table 1 represent traders from sixty-three different countries and indicate that the total number of reporting foreign traders is small. Further, most of them were located in Canada, Western Europe, and Australia. As one would expect, foreign traders were concentrated in the grains and soybean complex, foreign foodstuffs, industrial commodities, and precious metals.

The data in table 2 show that, except for foreign foodstuffs (coffee, cocoa, and sugar), the average percentage of open interest accounted for by large foreign traders was quite small, ranging on the long side from 1.5% for precious metals to 11.5% for industrial goods and on the short side from 1.9% for livestock and meat to 5.9% for financial instruments. Very little of the foreign participation came from the LDC's, with the exception of coffee (table 3), in which an average of 16.1% of the long open interest emanated from Central and South American accounts.[2]

Although these data suggest that foreign participation in U.S. markets was, on average, relatively small and that the LDC portion of that trading was very small, there was a good deal of variation in the amount of foreign par-

[1] These data, and those used in tables 1 through 3, were obtained from daily reports filed by futures commission merchants for each of their customer and house accounts that had a reportable position in a specific commodity future (for example, July soybeans). At the time of this study, a reportable position was fifty or more contracts in a single silver or cotton future, forty or more contracts in a single grain or soybean future, or twenty-five or more contracts in a single future in any other commodity.

These reports, called CFTC series '01 reports (the initial digit varies with the particular commodity), generate data needed for market surveillance by the Commission. Information on the position of individual traders is exempt from public dissemination under the Freedom of Information Act. The CFTC has not, to date, routinely published aggregated data based on the '01 reports.

[2] Since Central and South American nations are major producers of the coffee consumed in the United States, it may seem puzzling that their participation was largely on the long side; as producers one would expect them to be short hedgers. Several possible explanations emerge: (*a*) the accounts could be speculative, (*b*) they could emanate from exporters who had signed agreements to deliver coffee but had not, at the time, obtained the coffee domestically, or (*c*) the long positions could be held by exporters anticipating the need for stocks to replenish pipeline inventories.

Table 2. Percentage of the Open Interest for Selected Commodity Groups Held by Reportable Foreign Traders on Nine Month-End Dates, 30 June 1976–28 February 1977

Country Group[a]	Grains and Soybean Complex		Livestock and Meat		Domestic Foods		Foreign Foods		Financial Instruments		Industrial Goods		Precious Metals	
	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short
A (avg.)	2.8	2.8	3.3	1.9	6.2	3.9	21.2	24.6	2.9	2.7	9.8	5.6	1.5	1.1
A-1 (avg.)	2.6	2.4	3.3	1.9	6.2	3.9	20.6	24.6	2.9	2.7	9.8	5.6	1.5	1.1
U[b]	4.4	6.1	8.1	7.1	11.6	12.4	28.9	43.7	6.0	5.9	17.2	21.7	16.9	11.8
L	1.9	2.0	—	—	3.4	—	22.9	13.1	2.1	0.8	—	—	—	—
A-2 (avg.)	0.2	0.4	—	—	—	—	0.6	[c]	—	—	[c]	[c]	[c]	—
U	1.6	3.2	—	—	0.9	—	1.9	0.8	0.5	—	2.2	0.3	0.1	—
L	0.1	—	—	—	—	—	1.1	1.1	—	—	—	—	—	—
B (avg.)	0.1	[c]	—	—	—	—	1.1	1.4	[c]	2.2	[c]	[c]	[c]	[c]
U	0.3	0.3	—	—	—	—	3.7	2.3	2.2	6.6	0.3	1.3	0.8	0.2
L	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C (avg.)	0.4	0.7	[c]	[c]	[c]	—	1.9	[c]	1.4	—	0.8	[c]	[c]	[c]
U	1.7	6.8	0.2	0.3	1.7	—	25.2	1.5	4.6	—	2.1	0.3	3.6	0.4
L	—	—	—	—	0.4	—	0.7	1.2	—	—	—	—	—	—
D (avg.)	0.2	[c]	[c]	—	[c]	[c]	[c]	[c]	0.9	1.0	[c]	[c]	[c]	[c]
U	2.5	0.1	0.3	—	1.1	2.6	4.2	2.0	8.1	10.6	1.2	0.4	6.6	4.2
L	—	—	—	—	—	—	0.4	0.2	—	—	—	—	—	—
E (avg.)	0.1	[c]	0.9	—	[c]	—	[c]	[c]	—	—	0.9	[c]	[c]	1.1
E-1 (avg.)	—	[c]	—	—	—	—	—	—	—	—	[c]	[c]	—	—
U	—	0.1	—	—	—	—	—	—	—	—	0.9	2.1	—	—
L	—	—	—	—	—	—	—	—	—	—	—	—	—	—
E-2 (avg.)	0.1	[c]	0.9	—	[c]	—	[c]	[c]	—	—	0.9	[c]	[c]	1.1
U	0.9	0.1	8.2	—	0.7	—	0.4	0.1	—	—	1.8	1.1	4.8	30.9
L	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F (avg.)	—	[c]	—	—	—	—	[c]	[c]	—	—	—	[c]	[c]	—
U	—	0.1	—	—	—	—	[c]	[c]	—	—	—	[c]	[c]	—
L	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All countries (avg.)'	3.7	3.5	4.2	1.9	6.2	3.9	24.3	26.0	5.2	5.9	11.5	5.6	1.5	2.2

Source: CFTC series '01 reports (see fn. 1).

[a] See table 1 for countries included in each group.

[b] The maximum percentage of the open interest held by reporting foreign traders on any month-end date was computed for each commodity within a commodity group. The range shown in the tables represents the range of these maximum percentages within a commodity group. U indicates the upper end of the range; L indicates the lower end of the range.

[c] Less than 0.05%.

ticipation. For example, on one month-end date nearly 31% of the short positions in one precious metal was held by accounts from Southeast Asia. Also, on one month-end date, 25.2% of the long positions in coffee was held by Central and South American traders.

In summary, the above data do not support a contention that foreigners have lacked access to the U.S. markets. On the other hand, neither do these data support an assertion sometimes made that U.S. commodity markets are regularly dominated by foreign interests. This latter notion has led to repeated calls for a regulatory policy to "protect the markets"—a public policy issue that involves the trade-off between open access to the markets and potential market abuse by foreign interests that may be beyond the influence of U.S. law.

Good arguments can be made in favor of maintaining, as much as possible, open access to U.S. markets. Competition requires freedom of entry and exit, with markets reflecting all factors affecting price, including possible collusive policies followed by foreign countries. Even if foreigners are not granted access to U.S. markets, these institutions are not, in most instances, immune from collusive or manipulative actions taken in an alternative foreign market. Lastly, it can be argued that it is best to "have them where we can watch them."

Counterbalancing this open-access argument is a concern that foreign nations are privy to information about supply and demand conditions for some commodities that, irrespective of its informational value to the marketplace, provides them an unfair advantage. Second, where the commodity being traded is produced in only a few countries, it may be

Table 3. Foreign Foods: Percentage of Open Interest Held by Reportable Foreign Traders on Nine Month-End Dates, 30 June 1976–28 February 1977

Country Group[a]		Cocoa		Sugar		Coffee		Total	
		Long	Short	Long	Short	Long	Short	Long	Short
A	Avg.	27.2	29.4	20.6	25.3	13.6	8.6	21.2	24.6
A-1	Avg.	27.2	29.4	19.9	25.3	13.6	8.6	20.6	24.6
	Max.[b]	28.9	43.7	26.3	28.3	22.9	13.1		
A-2	Avg.	[c]	—	0.7	[c]	[c]	—	0.6	[c]
	Max.	1.9	—	1.1	0.8	1.5	—		
B	Avg.	—	[c]	1.5	1.8	—	—	1.1	1.4
	Max.	—	1.4	3.7	2.3	—	—		
C	Avg.	1.0	0.6	0.6	[c]	16.1	0.6	1.9	[c]
	Max.	2.5	1.5	0.7	1.2	25.2	1.2		
D	Avg.	[c]	0.6	[c]	[c]	1.8	0.9	[c]	[c]
	Max.	0.9	0.9	0.4	0.2	4.2	2.0		
E	Avg.	[c]	—	[c]	[c]	—	—	[c]	[c]
E-1	Avg.	—	—	—	—	—	—	—	—
	Max.	—	—	—	—	—	—		
E-2	Avg.	[c]	—	[c]	[c]	—	—	[c]	[c]
	Max.	0.4	—	0.4	0.1	—	—		
F	Avg.	—	—	[c]	0.6	—	—	[c]	[c]
	Max.	—	—	0.1	0.8	—	—		
Average all countries		28.2	30.6	23.4	27.7	31.5	10.1	24.8	26.0

Source: CFTC series '01 reports (see fn. 1).
[a] See table 1 for countries included in each group.
[b] Maximum percentage of the open interest held on any one month-end date by reportable foreign traders.
[c] Less than 0.05%.

relatively easy for several foreign nations to agree on collusive policies that can have a pronounced influence on the futures market. Finally, there are limited regulatory sanctions that can be effectively imposed against a foreign trader guilty of collusive or manipulative actions on the U.S. markets.

Despite the strength of these latter arguments, and because of the relatively small amount of direct foreign participation in U.S. markets, the most appropriate public policy approach to this issue appears to be maintaining open access to U.S. futures markets while improving the public information on foreign traders' activities in these markets.

Establishing Commodity Exchanges in LDC's

Requests by LDC's for assistance in establishing commodity exchanges normally reflect false hopes that a local futures exchange could increase a country's market power and control over its export markets, result in higher prices, and improve a country's international image. Further, there is a general belief that, if they just "will" the existence of a commodity exchange in their country, such a market will spring forth full blown as Athena from the head of Zeus.

Although these objectives are not likely to be achieved through a commodity exchange, a number of LDC's are nevertheless pursuing the establishment of exchanges. This section of the paper examines some of the issues related to developing commodity exchanges in LDC's, with particular emphasis on exchanges as multiplier-type institutions that provide linkages useful in the development of an economy.

Commodity exchanges are financial institutions, and futures contracts are financial instruments. Exchanges can thus be useful in mobilizing the savings available in a society and stimulating investment. Typically, the low savings levels in developing countries result not only from the subsistence living standard of a large portion of the population but also from the lack of an adequate infrastructure to mobilize savings.

The contribution of an exchange to the savings-investment flow and the capital stock depends most heavily on the participation of speculators and the existence of a clearinghouse. The role of speculators is important, since they provide not only the liquidity and

market positions to carry the hedge load at low cost but also large amounts of financial resources that ultimately become available for investment.

The clearinghouse acts as the financial center for the exchange—verifying and guaranteeing transactions, collecting and dispersing settlements. Clearinghouses that undertake these responsibilities require large amounts of funds that are obtained through cash deposits (called margin) made by both parties to the transactions. These funds, drawn from diverse locations within and outside the country, generate local bank deposits and bank reserves for lending. For example, in Chicago, where 75% of U.S. futures trading is conducted, it is estimated that clearinghouse members maintain daily cash balances of approximately $200 million to meet daily settlements, plus another $800 million to $1 billion in margin deposits, usually denominated in T-bills (estimates obtained from Chicago banks, see Powers). A significant proportion of these funds (the exact amount is not known) are generated outside of Chicago, mainly in California, Texas, New York, and Iowa, where, along with Illinois, the largest number of futures traders are located. It seems doubtful that these funds would have been deposited in Chicago had the exchanges not been located there.

The accumulation of these deposits in one locale generates some obvious economies of scale in the lending function and establishes a level of commodity lending expertise not normally available elsewhere. Thus, it is no accident that banks that act as the principal depositories for such monies also tend to become the leading banks in lending for the production, processing, storing, and marketing of commodities.

These bankers learn that hedged collateral is less risky than unhedged collateral. Consequently, less equity may be required of hedged borrowers, and lower interest rates can be proffered to customers pledging hedged collateral. The impact of this activity on real investment could be significant. The lower interest rates proffered could result in a movement down the marginal efficiency of investment schedule as the supply of loanable funds increases. Further, it could also produce an outward shift of the investment schedule and a change in the ranking of alternative investment projects. To illustrate, Robert Parrott, vice-president of Central Soya Company, Inc., stated at a Commodity Futures Trading Commission (CFTC) hearing that without the broiler futures market his firm might still have made an investment in broiler production, but it is likely that the size of the investment would have been significantly reduced. Because the futures market allowed the firm to reduce risk, it lowered the required rate of return on funds allocated to the broiler enterprise.

In addition to mobilizing domestic savings, an exchange may also attract foreign exchange earnings that one would expect to impact first on the aggregate demand function and ultimately on the savings-investment flow. As a consequence, the investment level in the country should rise. Such foreign exchange earnings should increase a country's hard currency reserves. Furthermore, to the extent that an exchange attracts foreign speculators, it shifts to outsiders risks that might otherwise be carried by the domestic economy.

Foreign exchange earnings can be generated by a commodity market from commissions paid to domestic brokers by foreign traders, interest earned on margin deposits at the clearinghouse, and the excess (if any) of foreign participants' losses over their gains. Further, the existence of the exchanges frequently generates considerable business in physicals. The size of these earnings on invisibles can be significant in a country's balance on current account. A recent survey by the Bank of England indicates that from June 1974 through May 1976 the British commodity futures markets generated inflows of about 148 million pounds sterling. In addition, another 245 million pounds sterling were generated in physicals.

Of the three elements affecting the balance-of-payments flows from futures markets, the most variable is the gains and losses by foreign traders—speculators, hedgers, and straddlers. If foreign speculators lose more than they win, their net losses represent a balance-of-payments credit; if they are successful, their net gains represent a balance-of-payments debit. If one assumes that foreign hedgers are long hedgers who buy the cash product and export it from the LDC, any losses suffered in the futures market will result in a positive flow of funds into the LDC. If there are gains on the futures positions, those gains will represent domestic currency that can be applied against the purchase of the product. Accordingly, these gains by long foreign hedg-

ers represent a foreign exchange opportunity cost for the LDC because, had the product not been hedged, additional external funds would have been earned from the sale of the cash commodity. To the extent the foreign hedgers are short hedgers and suffer losses (gains) on their futures positions, the balance-of-payments flow will be positive (negative).[3]

The potential balance-of-payments flows associated with straddle positions are a bit more complex and unpredictable, depending upon the relative distribution of straddles, the degree to which one country's price adjusts relative to the other country's price adjustment, and changes in price levels. Assume there are two futures markets for the same commodity, one located in an LDC (the secondary market) and one located in a developed country (the primary market). Assume also that straddles are entered into only when the markets have moved away from their normal equilibrium and that all straddles are accurately successful, i.e., the market always returns to its appropriate equilibrium. Then, if straddlers in the two countries are equally distributed between the markets, and if following a situation of disequilibrium one country tends to adjust more than the other, then the country that adjusts more should experience an outflow of funds with respect to the other country. According to McClay, the loser is more likely to be the country that is the secondary market or, in this instance, the LDC.

McClay also shows that when the price level changes during the life of a straddle, the balance of payments of the secondary market is affected more unfavorably by a predominance of wide straddling (long the market that is normally lower and short the market that is normally higher) in a price fall or narrow straddling (long the market that is normally higher and short the market that is normally lower) in a price rise. In the long run, he believes that price level changes are also likely to be more unfavorable to the secondary market than to the primary market.

If it is true, as stated earlier, that many LDC's want commodity markets for the wrong reasons, it is probably equally true that many countries that want exchanges are not sufficiently developed to support them. An exchange requires a threshold level of infrastructure in order to emerge as a viable institution. The following elements are important in measuring that threshold level.

(*a*) Fast and efficient communications, both domestic and international, are necessary in performing the all important information dissemination function of the exchange and in providing the key element of visibility.

(*b*) Grades, standards, and quality control procedures of a minimal nature are needed to describe the commodity accurately in contract specifications.

(*c*) Minimal transportation and storage systems must be available to move products from buyers to sellers.

(*d*) A financial system capable of supporting capital transfer, short-term credit needs, and special types of debt instruments is necessary to facilitate the functioning of the clearinghouse.

(*e*) The potential for commercial hedging must exist. Experience in the United States has taught that the broader the potential hedge participation, the greater the chance that a market will function properly and that commercial users will benefit from the exchange's operation. Experience also demonstrates that most producers do not hedge.

(*f*) A legal system that recognizes and enforces the rights and duties embodied in contracts is important in generating confidence in an exchange.

In addition, as noted in the preceding section, international access to the market and speculative capital are important elements in determining the viability and economic contribution of an exchange. International participation allows risks inherent in the domestic economy to be dissipated over the wider international market and provides important linkages between the domestic economy and world markets. Central to attracting this foreign participation is foreign currency convertibility at reasonably low cost and risk. Speculative capital provides liquidity and competition in the marketplace and generates many of the externalities associated with the exchange. Ironically, many LDC's who want commodity exchanges also condemn speculative participation in the markets as unnecessary and evil.

Even with all of these elements present in an LDC, there may still be many impediments to the development of a properly functioning commodity exchange. It takes time and a great

[3] Space does not permit an exploration of other possible cases in which the balance-of-payments effects might be different. However, it appears that in most instances these cases should produce balance-of-payments repercussions similar to those associated with foreign speculation.

deal of educational effort to build credibility, confidence, and understanding of an exchange and its role.

Futures Markets and International Commodity Agreements

Concurrently with their exploration of increased use of futures markets, LDC's have pursued widely publicized efforts to obtain assistance from industrialized countries in establishing a Common Fund to finance buffer stocks in major commodities. Interesting theoretical and philosophical questions are raised by LDC's simultaneous pursuit of buffer stock financing and access to futures markets. These issues include the compatibility of the two institutions and the extent to which (as has been suggested by McKinnon and Houthakker) official intervention (either by LDC's acting as a group or jointly with developed countries) in futures markets is a viable substitute for buffer stocks. Unfortunately, this is an area that, at present, involves many unanswered questions that cannot be settled here. However, since the relationship between futures markets and buffer stocks involves significant policy issues, it appears worthwhile to raise questions whose further consideration should provide insights and inputs to policy recommendations.

The explicit goal of buffer stock programs is to decrease price variability and possibly (depending on the direction of quantity changes) income variability. An implicit objective of buffer stock programs often appears to be stabilizing commodity prices at levels that would be, on average, higher than those that would have been established by market forces alone. Alternately, authorities could buy and sell contracts in the futures market in their attempt to reduce price fluctuations or maintain commodity prices at higher than equilibrium levels. Price elevation, however, is not an appropriate economic objective for either buffer stocks or forward market intervention. The tenets of welfare economics dictate that when a good's price reflects its social as well as its private costs and benefits, it is inefficient for the government to influence that price to effect a redistribution of income. Rather, lump sum taxes and transfers are considered the preferred means of income redistribution.

In addition, the use of buffer stocks to keep prices of primary goods above their long-term equilibrium level should be expected to encourage overproduction and to leave the buffer manager, as buyer of last resort, with an ever-growing stockpile of the commodity. In order to maintain futures prices above their long-run equilibrium level, authorities would normally be holding net long positions and taking losses on these contracts as they neared maturity. Further, such price-supporting activities would necessitate taking delivery on futures contracts. In such a situation, intervention in the futures market would become less a substitute for the maintenance of buffer stocks than an alternate means of obtaining these stocks.

Furthermore, if authorities attempt to elevate prices in futures markets, speculators should soon realize that the futures price is an upwardly biased estimator of the expected spot price in the future. Speculators would therefore be likely to join producers in selling short in the forward market. Official eagles would become sitting ducks, providing one-way options to speculators (as happened to numerous central banks that resisted currency devaluations or revaluations during the 1960s and early 1970s).

Houthakker and McKinnon,[4] comparing official intervention in domestic spot and futures markets for agricultural products, conclude that intervention in futures markets should be the less costly means to reduce the variability of farm prices. Houthakker extended his analysis to apply "not only to the domestic commodity markets, but perhaps even more to the international ones. . . . Buffer stocks schemes . . . involve considerable financing; by working through the futures market, as proposed here, the financial aspects can be considerably improved" (p. 59).

Several empirical and theoretical issues arise in choosing between official intervention in futures or spot markets to stabilize commodity prices. First, the mechanism that transmits price changes from the futures to the spot markets must be strong enough so that intervention in one market can be considered a good substitute for intervention in the other. It is interesting to speculate how many of the

[4] McKinnon's prescription was for the government to make a market in the far distant (beyond the next crop year) futures contract so that primary producers could hedge their future income, yet make their planting decisions on the basis of more timely data. Houthakker suggests that the government buy and sell futures contracts to reach target prices (based on a three-year moving average of past prices) for the six- to nine-month futures market.

several score active futures markets would possess the depth, breadth, and resiliency to withstand official intervention and to transmit, predictably, price changes to the spot market.

In this respect, the market for forward foreign exchange might be illuminating. There is a rich literature, starting with Keynes, that theorizes that the (annualized) discount of a country's forward exchange rate over its spot rate should equal the short-term interest rate differential in favor of that country. Thus, by influencing the forward exchange rate (with interest rate differentials unchanged), the spot price of foreign exchange should be changed in the same direction and by the same amount.

Despite the elegance and intuitive attractiveness of the interest-parity theory of the determination of forward and spot exchange rates, this exact relationship has seldom been seen empirically, in part because of the market conditions in many financial centers. Capital controls inhibit arbitrage transactions, forward markets are normally less well developed than spot markets, and the opportunity cost of interest arbitrage should rise with the proportion of portfolios held in a foreign currency.[5]

Second, when there exists a stable and predictable relationship between futures and spot prices, it might be asked (as McKinnon and Houthakker do) which form of intervention should be less costly for a given quantity of price stabilization. Under the *ceteris paribus* assumption made by these authors, intervention in futures markets would appear to require a smaller net outlay of resources. However, this issue may not be one in which marginal cost-benefit analysis is applicable. Extensive official buying and selling on futures markets by an international fund could alter the nature of commodity markets by changing the magnitude and direction of the positions taken by private participants in the market.[6] Thus, two further questions arise. (*a*) What is the nature of the trade-off between price stabilization through official intervention and the weakening of futures markets? (*b*) How does this trade-off change as a function of which market (spot or futures) is used for official purchases and sales?

Third, McKinnon and Houthakker implicitly assume that of the three groups of market participants—hedgers, speculators, and arbitrageurs—officials should play the role of stabilizing speculators or market makers. However, developing countries might be better served by acting as hedgers, taking advantage of opportunities for transferring price risks. As noted by Tomek and Gray, producers' incomes will be stabilized by their hedging expected production in the new crop futures market if futures prices vary less than cash prices from year to year. This third point provides the basis for an important policy consideration, namely, whether private sector activity in futures markets can stabilize prices comparably with buffer stock management in cash markets or official intervention in futures markets. The existence of a futures market should encourage the development of storage facilities and the carrying of inventories by the private sector and thereby should have a leveling effect on prices over time.

The choice between private futures markets or official intervention in the cash or futures markets to stabilize prices is a philosophical, as well as a theoretical and empirical, one. The promotion of futures exchanges to shift risk and encourage the private holding of inventories is an approach that emphasizes a solution in the private sector. The publicly held buffer stock approach involves, of necessity, a significant degree of official management of major markets. The ramifications of official intervention in futures markets may be quite large and unfavorable. Caution appears advisable lest, in the quest for a slightly less expensive means of smoothing price fluctuations, a viable and important pricing institution, with all of its positive externalities, might be weakened. If LDC's develop futures markets, officials of these countries should be discouraged from intervening in such markets, since such a policy would undoubtedly doom a new market.

Summary and Conclusions

Access to commodity exchanges may make important contributions to the ultimate objec-

[5] Interestingly, during the period of generalized floating the financial press reported that only the Bank of England has undertaken significant intervention in the forward market, as the British central bank had done during the mid-1960s (at which time it suffered significant losses when sterling was eventually devalued in 1967). The question may be asked why Britain, but reportedly no other major country, chose to use forward as well as spot intervention to moderate fluctuations in the price of its floating currency. The answer may lie in the special characteristics of the British situation: an open economy, a depreciating exchange rate, dwindling reserves, a developed forward market, and few limitations on capital inflows.

[6] Of course, as Gray suggests, the *ceteris paribus* assumption might also be inapplicable following significant official buying and selling in cash markets.

tives of LDC's—price and income stability and the development of indigenous resources. Among the potential benefits accruing to LDC's from futures markets are (*a*) increased integration of developing countries' pricing systems into world markets (to the extent that this integration effects greater substitution between commodities, one might expect a rise in the price elasticities of exchange-traded commodities); (*b*) a broadening of competition and a reduction of monopsonistic power; (*c*) a dissipation of the domestic risk load to the broader world economy; and (*d*) a strengthening of the financial infrastructure, with changes in the savings and investment functions, in developing countries that establish commodity exchanges.

If, as suggested above, futures markets offer positive externalities to LDC's, one might expect to observe an increase in LDC's participation in existing futures markets located in industrialized countries and the development of "regional" futures markets on the fringes of major LDC areas. Such efforts are already under way in Hong Kong, Brazil, and Malaysia-Singapore.

Foreign access to the U.S. futures exchanges should be kept as open as possible in order to avoid discouraging LDC's participation in futures markets and to further the competitiveness of U.S. markets. Consistent with this policy of openness would be an expanded informational effort by the CFTC to ascertain the extent of foreign participation in the U.S. markets. Such data should be aggregated to the extent necessary to protect the identity and size of individual holdings.

Lastly, complex theoretical and empirical issues are involved in substituting official intervention in futures markets for intervention in spot markets to moderate price fluctuations. These issues include the nature and strength of the transmission mechanism between spot and futures prices; the effect of extensive intervention in futures markets on private participation in such markets; and whether private hedging in futures markets, and the possible concomitant encouragement of private inventory building, may go a considerable way toward reaching the price and income stability currently sought by developing countries.

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Commodity Options for Agriculture

Bruce L. Gardner

This paper considers the potential benefits of trading in options for farm commodities in three areas: risk management by individuals, the functioning of commodity markets, and the management of public policy with respect to farm products.[1]

Individual Risk Management Using Options

To review the terminology used, a "commodity option" is a contract to buy or sell a given quantity at an exercise price stated in the contract at the option of the purchaser of the contract. A contract conveying the right to buy is a "call" option. A contract conveying the right to sell is a "put" option. While an option confers the right to buy or sell, there is no obligation to do so. The right is not a free lunch, however, because the option must be paid for, whether it is exercised or not.

The person who receives payment, the other party to the contract, is said to "write" the option. He has a responsibility but no rights, for which he is paid. For a call (put) option, if the commodity price rises above (falls below) the exercise price by more than the "premium" paid (number of bushels in the contract divided by amount paid for the contract), the buyer of the option comes out ahead. If market prices does not rise this high (fall this low), the option writer gains. The gains of one party equal the losses of the other.[2]

There are four roles an individual may play in options contracting: one can buy a call option, write a call option, buy a put option, or write a put option. Any of these actions may either increase or decrease an individual's exposure to price risk depending on his position in the underlying commodity, in futures, or in other options.

Hedging using futures contracts provides a standard with which risk management by means of commodity options may be compared. The essential difference is that, while futures ideally determine price in advance for a hedger, an option fixes price over a range of market outcomes while confronting the individual with the market price over a different range. The results of a put option hedge by a producer are shown in figure 1. An option to sell at price P^*, for which the premium paid is V per bushel, guarantees returns of $P^* - V$ per bushel for market price below P^* but permits revenues to increase at higher prices. Numerical examples are presented below.

Whether hedging with put options is preferred to a forward sale would depend on the producer's utility function. The option would have appeal, for example, to a farmer having a utility function of the form suggested by Friedman and Savage to account for simultaneous insurance and gambling—risk aversion in the face of large losses but risk preference in choice between average and unusually large gains.

Even if a producer is uniformly averse to risk, options are promising in risk management when one moves away from the idealized circumstances in which a futures sale determines returns per bushel in advance. In more realistic cases in which output is stochastic, or when basis risk exists, futures are less effective in reducing risk. The variance of receipts in some such cases has been analyzed by McKinnon and by Peck. In the circumstances that McKinnon analyzes,

Bruce L. Gardner is a professor in the Department of Agricultural Economics, Texas A&M University.

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[1] Trading in commodity option for most domestic farm products (notable exceptions being sugar and tobacco) is currently prohibited by the Commodity Exchange Act. The occasion is appropriate to consider the economics of options because of the Commodity Futures Trading Commission's proposed pilot program in options trading for some nonprohibited commodities, which could open the door to a general relaxation of restrictions on options.

[2] Brokerage or other transactions costs are for the most part ignored in this paper, so that the premium paid by an option buyer equals the receipts of the option writer. The analysis also is oversimplified in not considering the distinctions between "American" and "European" options (defined below) or between options written on a commodity and options written on a futures contract. The basic economics of options is not affected by these complications, although they involve important practical issues.

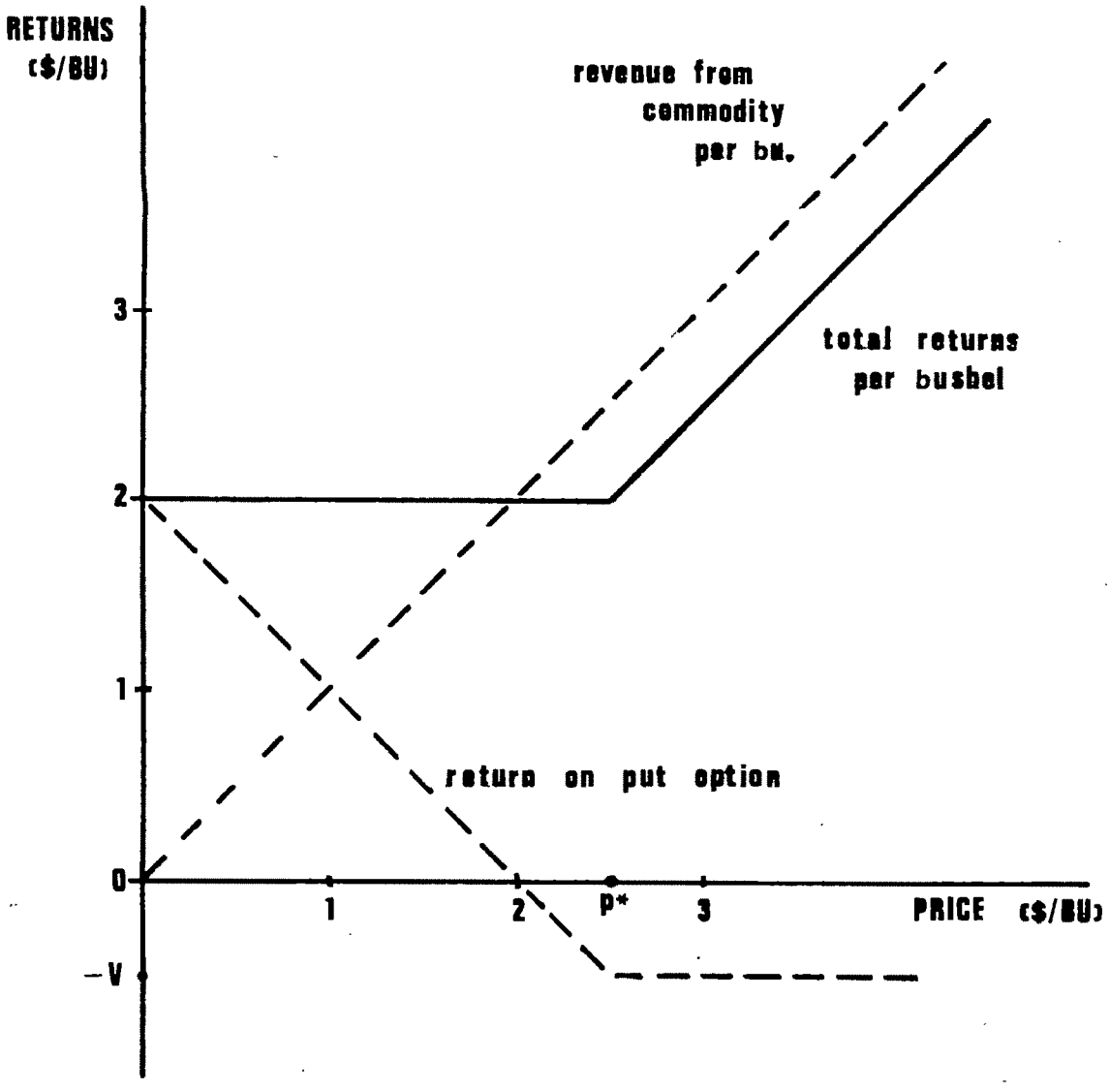


Figure 1. Returns per bushel for a hedging purchaser of a put option

where a farmer's output is negatively correlated with price, options can duplicate and even improve upon the stabilization of receipts attained by a forward sale.

To illustrate, suppose a producer faces the following situation: expected crop price is $3.00 per bushel, at which price it pays to commit $20,000 in contractually paid inputs together with owned resources normally sufficient to produce 9,000 bushels. Let there be five possibilities for market demand and the individual's yield, each with a probability of one-fifth, as shown in table 1.

There are only three quantity outcomes, but price may vary for a given crop size because of demand shifts and because other farmers sometimes have good crops when a particular farmer has a poor crop. Nonetheless, when poor weather reduces yields and increases prices for the market, it tends to do so also for a representative producer. Thus, a typical producer tends to observe negative correlation between yields and prices.

If the producer sells forward his entire normal crop of 9,000 bushels, he does poorly in outcomes (*a*) and (*b*) because he must buy to cover part of the forward sale at increased prices. The income results are shown in the sixth line of table 1.

McKinnon's formula for the optimal for-

Table 1. Producer Outcomes under Futures and Option Hedging

	(a)	(b)	(c)	(d)	(e)	Mean	Standard Deviation
Market situation							
Probability	0.2	0.2	0.2	0.2	0.2		
Quantity (1,000 bu.)	8	8	9	10	10	9	
Price ($/bu.)	4.00	3.50	3.00	2.50	2.00	3.00	
	----------	----------	----------	$1,000	----------	----------	----------
Market revenue	32	28	27	25	20	26.4	3.93
Income*	12	8	7	5	0	6.4	3.93
Forward sales							
Income, 9,000 bu. sold forward	3	3.5	7	9.5	9	6.4	2.71
Income, optimal forward sale	6	5	7	8	6	6.4	1.02
Optimal forward sale plus option							
Cost of option	0.3	0.3	0.3	0.3	0.3	0.3	
Returns from option	1.0	0.5	0	0	0	0.3	
Income	6.7	5.2	6.7	7.7	5.7	6.4	0.87
Two-option hedge, no forward sale							
Net gain on writing call	−3.6	−1.6	0.4	2.4	2.4	0	
Net gain on buying put	−1.0	−1.0	−1.0	−1.0	4.0	0	
Income	7.4	5.4	6.4	6.4	6.4	6.4	0.63

* Revenue minus contractual costs of $20,000.

ward sale as a fraction of expected production works out in this example to about two-thirds, implying a forward sale of 6,000 bushels.[3] With a futures sale of 6,000 bushels, receipts are $18,000 from the forward sale plus the market value of additional production. The income results are presented in the seventh row of table 1. This strategy yields the same average income as selling forward the entire average crop of 9,000 bushels, but it gives more stability in returns.

Consider the use of options. In the optimally hedged position, income is lower in the high price outcomes. Therefore, an option stabilizes returns if it makes money when prices are high and loses money when prices are low. Let the farmer buy a call option for 1,000 bushels at $3.00. The expected value of the option when exercised is 0.2($4.00 − $3.00) + 0.2($3.50 − $3.00) = $0.30 per bushel. In a competitive options market, this is about what the farmer has to pay for the option.[4] The results are shown in lines eight through ten of table 1. The option transaction enables a reduction in income variability in addition to that attainable by the optimal futures sale. Mean income is the same in all cases because the expected return to options trading is zero. However, there is a real cost to the stabilization attained, namely, the brokerage fees that are left out of these calculations. The producer's choice is whether the stabilization of income attainable is worth these fees and other transaction costs that will be incurred.

Returning to the original unhedged position, it may be asked whether futures might not be dispensed with altogether. Since stabilization is achieved by reducing incomes in high price years, it is natural to consider writing a call as a substitute for the futures sale. Indeed, in this example simply writing a call option for 6,000 bushels at $2.00 duplicates the income results of the optimal futures sale of 6,000 bushels.

Finally, consider the following example in which futures transactions are replaced by two option hedges—writing a call option on 4,000 bushels at $2.50 (to reduce income under high prices) and simultaneously buying a put option to sell 10,000 bushels at $2.50. The payment to the farmer for writing the call option is 0.2(2.50 − $2.00) + 0.2($3.50 − $2.50) + 0.2($3.00 − $2.50) = $0.60 per bushel, and the cost of the put is 0.2($2.50 − $2.00) = $0.10 per bushel. The income results are shown in lines eleven through fourteen of table 1. This strategy yields a standard deviation of income lower than any yet considered.

Generally, a strategy of writing calls and

[3] The formula is forward sale/expected output = $[\rho\sigma_x/x]/[\sigma_p/p] + 1$, where ρ is the correlation coefficient between price and output (about −0.8 in the example, which is much greater than one would typically expect), and σ_x/x and σ_p/p are the coefficients of variation of output and price, respectively (McKinnon, p. 848).

[4] Not including brokerage fees. This assertion depends on there being no risk premium to speculators or else that speculators (individuals who increase their risk as a result of the transaction) are equally prevalent on the buying and selling side.

buying puts would be expected to compare favorably with an optimal forward sale. However, it is much more difficult to use options when the set of possible outcomes is unknown or is more complicated than in this simple example. Generally applicable optimal strategies for using options in hedging have not yet been developed. The point here is to show that options have promise for limiting price risk with more flexibility than futures allow.[5]

Options and Commodity Markets

The effect of options on the market for the underlying commodity should be similar to the effect of an improved form of insurance in any risky activity. More risk-averse participants should be drawn into the activity and should require smaller risk premia in their noncontractual returns. The introduction of commodity options should therefore tend to increase output and reduce prices. It might be expected, however, that any reduction in price would be quite small because fairly good substitutes as instruments for reducing risk already exist.

Baumol argues, as an instance of the general argument that speculative activity tends to be stabilizing, that options tend to reduce instability in the price of the underlying commodity because they increase the supply of speculative services. Apart from this effect, there is no a priori reason to expect an options market to affect price fluctuations in the underlying commodity, even though market participants can use options to control the risk they face as a result of these fluctuations.

A possibly more important result of options trading is the public information that can be inferred from the selling price of an option. Just as futures prices generate information about expectations of commodity prices, an option's price generates information about expectations of the variability of commodity prices.

The present value of a call option to be exercised at time t, is[6]

$$(1) \qquad V = e^{-rt}\int_{P^*}^{\infty} Pr(P_t)\cdot(P_t - P^*)\mathrm{d}P_t,$$

where P^* is the exercise price, $Pr(P)$ represents the probability density function of price at t, and r is the appropriate interest rate. If the probability distribution of price takes a form that can be represented by the mean ($\bar{P}_t$) and variance (σ^2), an estimate of $\bar{P}_t$ is consistent with only one value of σ^2, given the values of r and V. An estimate of $\bar{P}_t$ is available for some commodities from the appropriate futures price. An estimate of V is available from observation of the premium in the options market. Therefore, σ^2 can be estimated if an options market exists. The following discussion shows how.

Under log-normality,[7] equation (1) becomes

$$(2) \qquad V = \frac{e^{-rt}}{\sigma\sqrt{2\pi}}\int_{P^*}^{\infty}\frac{1}{P_t}\exp\left[-\left(\frac{\ln P - \overline{\ln P}}{\sigma}\right)^2/2\right](P_t - P^*)\mathrm{d}P.$$

Let $z = (\ln P_t - \overline{\ln P})/\sigma$, where σ is the standard deviation of the log of price. Then expanding to a P_t and P^* term, completing the square on $w = z - \sigma$ to integrate the P_t term, and using the fact that $\ln\bar{P} = \overline{\ln P} + \sigma^2/2$, where $\ln\bar{P}$ is the log of the mean and $\overline{\ln P}$ is the mean of the logs, the result is

$$(3) \qquad V = e^{-rt}\left\{\bar{P}_t N\left(\sigma + \frac{\overline{\ln P} - \ln P^*}{\sigma}\right) - P^* N\left(\frac{\overline{\ln P} - \ln P^*}{\sigma}\right)\right\},$$

where N is the cumulative normal distribution.

Since $\ln\bar{P} - \ln P^* = \ln(\bar{P}/P^*)$, dividing through by $\bar{P}$ yields

$$(4) \qquad V/\bar{P}_t = e^{-rt}\left\{N\left[\frac{\sigma}{2} - \frac{\ln(P^*/\bar{P}_t)}{\sigma}\right] - (P^*/\bar{P}_t)N\left[-\frac{\sigma}{2} - \frac{\ln(P^*/\bar{P}_t)}{\sigma}\right]\right\}.$$

[5] Although this discussion has dealt with producers who want to reduce risk, it should be noted that options also provide more flexibility for commodity purchasers and for speculators.

[6] This discussion considers only "European" options (exercised at the expiration date). Merton's discussion of options on securities indicates that it would typically pay to hold an "American" option (which may be exercised at any date until the expiration date) until expiration so that the two types would have roughly equal values. Black derives an equation equivalent to equation (4) under a time series of random changes in the commodity price, with changes distributed log-normally. However, the time series of agricultural commodity prices is not random in the same way as security prices because of seasonal factors. For example, an American call option for November soybeans, purchased in May, should be worth more than the corresponding European option because one would often wish to exercise the American option at the seasonal price peak in August. Therefore, hedging producers who are concerned with the November price would find European more efficient than American commodity options. However, an option to buy or sell a futures contract does not involve these problems, since there should be no seasonal in a particular futures contract's price.

[7] The log-normal distribution probably gives the best simple representation of the distribution of expected price. It is preferable to the normal distribution because negative prices are ruled out and equal percentage moves up and down, e.g., doubling and halving are equally likely.

Given the values of r and t, equation (4) contains three unknown quantities: $P^*/\bar{P}_t$, the exercise price relative to the expected price; $V/\bar{P}_t$, the value of the option relative to the expected price; and σ, the log standard deviation of expected price. With $\bar{P}_t$ from a futures market and an options market to generate P^* and V, we can calculate the implied σ.[8]

A test for the robustness of the estimated σ can be done easily if call options at different exercise prices are available. Each should yield the same estimate of σ. Even more useful as a check is the estimate of σ from the premium on a put option, which gives an estimate of σ based on the distribution of expected price in the low end of the price range.

Given the estimate of σ, it is possible to estimate the probability that price at t will be below or above any particular value. As with futures prices, it is unlikely that one will find any better estimate than the market's. This information could be helpful to a farmer in making production choices or to policy makers considering alternative price support levels. It would be a valuable byproduct of a market in farm commodity options. Since it would probably not pay for a producer to develop this information for himself, and since the information would be difficult to market by specialized firms owing to its public-good character, there may be reason actively to encourage and even subsidize options markets for their positive externalities.

Options and Farm Commodity Programs

The existence of an options market would clarify discussion of some aspects of farm policy and could facilitate the operation of some commodity programs.

Support prices as established by nonrecourse loans are equivalent to a put option. The producer has the right but not the responsibility to deliver the commodity to pay off the Commodity Credit Corporation (CCC) loan. The farmer has the same protection as if he had purchased a put option on a commodity market with an exercise price at the loan level. The difference is that the farmer does not pay for the CCC put option. Indeed, the economic value of the transfer from taxpayers to farmers each year is roughly the price that would have to be paid for put options to sell each year's crop at the loan level. This formulation makes clear that support prices have real economic value to farmers (and costs to taxpayers) even in years when market prices turn out to exceed support prices.

A major rationale for price support programs would disappear if a well-functioning market in put options existed. Each farmer could choose the degree of price insurance he wanted by purchase of a put option at the appropriate exercise price. Of course, the higher the insured price, the more the farmer would have to pay for his put option. If a farmer wanted a complete forward sale, he could sell futures or some other form of forward contract. The key feature of the put option is that it duplicates the kind of protection farm programs give—a price floor but no limit on profits from high prices—yet put options have neither the income redistribution nor resource allocation effects that price support programs do.[9]

Even if one believes that farm commodity programs should have income redistribution and resource allocation effects, options are potentially valuable in administering commodity policy. Although the existence of an options market may not have significant price effects, government intervention in this market can be used to change commodity prices just as intervention in futures or spot markets can. For example, call options could be a useful tool to government in management of grain reserves under an international agreement.

[8] Example: Suppose $\bar{P}_t$ = \$3.00 and an option to buy at P^* = \$3.30 sells for V = \$0.30 for a six-month option with r = 0.05. The value of σ that equation (4) implies is 0.36. If the option sold for less, say, \$0.15, then the implied σ is smaller, 0.22. When we observe the premium on an option whose exercise price equals the futures price, equation (4) is greatly simplified, and $V/\bar{P}$ depends only on σ. Also, observation of an option premium does not allow an estimate of expected price. If an option to buy at \$3.30 sells for \$0.30 per bushel, this does not imply a market expectation of a future price of \$3.60. However, observation of the market value of two options simultaneously allows inferences to be made about both the mean and standard deviation of expected price even without a futures market. The simplest case occurs when the exercise price P^* at which a put and call option have the same value is observed. Then, value of put = value of call:

$$\int_0^{P^*} Pr(P)\cdot(P - P^*)dP = \int_{P^*}^{\infty} Pr(P)\cdot(P^* - P)dP.$$

Rearranging terms,

$$\int_0^{\infty} Pr(P)\cdot P dP = \int_0^{\infty} Pr(P)\cdot P^* dP.$$

i.e., $E(P) = P^*$, expected price is the exercise price.

[9] There is an important difference in that a put option would probably expire within a year or so, while government programs ostensibly provide a price floor for longer periods. However, the permanence of government forward price guarantees should not be overstated. In the past when market prices have rested on support levels, support levels have tended subsequently to decline despite attempts to avoid this necessity by means of production controls, export subsidies, etc.

Such an agreement would probably require the United States to supply grain to the world market under some specific conditions. While most countries would meet such obligations by sales of government-owned stocks, the United States likely would prefer to rely on its well-developed private storage industry. Then delivery of grain under the international agreement could be guaranteed by acquiring call options from farmers or commercial sources.

An alternative to purchase of call options would be to extract a price from farmers for the CCC put option that current law establishes, the price taking the form of farmers giving the government a call option to buy grain at, say, twice the loan level in exchange for the farmer's option to sell at the loan level. The farmers, as owner of the put option and writer of the call, have effective control of the commodity at prices above the loan level but below twice the loan rate. The government, as owner of the call option and writer of the put, would have effective control of grain at prices below the loan and above twice the loan level. This seems a very natural arrangement for stabilization policy.

Some Objections to Options Markets

The objections to legalizing options trading seem to center on the difficulty of policing this activity and on alleged undesirable effects on competing financial markets, particularly futures markets.

The idea that any activity should be prohibited because of the difficulty of policing or regulating it seems to me a weak one. Options trading is a voluntary capitalist act between consenting adults, in Robert Nozick's phrase. People ought to have the right do these things unless it can be shown that serious external harm results. The regulatory view is that people ought to be forbidden from doing these things unless it can be shown that external good results. The regulatory view gains acceptance in the case of options because of the aura of disrepute about options trading. While options have the reputation of being inherently more purely speculative than futures trading, this reputation is undeserved. Options can be used either to increase or decrease risk of loss, just as futures or other wagers can. Options, however, are more flexible than futures, as illustrated above. Even for pure speculators, options can offer better controlled gambles than futures. In buying a call option the purchaser's maximum loss is limited by what is paid for the option. In futures trading or holding the commodity, losses are not so easily limited.

It is sometimes suggested that because the supply of speculative services is limited, the proliferation of options markets would reduce the viability of futures markets. This is an empirical issue that the Commodity Futures Trading Commission's proposed experimental program in options trading may help answer. Even if futures and options markets turned out to be such close substitutes that they could not coexist, can we be certain that the contest should be decided in advance in favor of futures?

It must be admitted, however, that there are many difficulties in establishing and facilitating trading in an options market and in keeping the public's trust in the integrity of such markets.

Summary and Conclusion

The effects of options trading in farm commodities cannot be established other than hypothetically since there is so little empirical evidence. Nonetheless, there are good reasons to expect that commodity options for farm products would be useful financial instruments. They can be used by producers and users of commodities for risk management purposes more flexibly than futures or other forward sales. They also present advantages to speculators. Their use could improve efficiency in the market for the underlying commodities. An organized options market would yield information about the distribution of expected market price that cannot be obtained from futures prices. This information would be useful for decision making in the private sector and for such purposes as setting support prices in the public sector. Finally, over the long term options could permit a further movement toward less reliance on the general taxpayer for farm income and greater market determination of prices and resource allocation in agriculture, while still permitting farmers to obtain a degree of insurance against the income consequences of low prices (without locking themselves out of the benefits of high prices as a forward sale does).

However, the private benefits of centralized

option trading could be insufficient to cover the costs of maintaining and transacting in such a market. If so, viable options markets will not develop. Nonetheless, there is no justification for stacking the deck against options by means of legislation. Indeed, the public good aspect of information generated by quoted option prices suggests that options trading on organized exchanges should be encouraged.

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Discussion

Ben W. Gunn

In choosing to concentrate on Powers' paper, I am not in any way ignoring Gardner's important contribution on the potential use of options. I share the doubts Powers has about the feasibility of using futures trading to permit a governmental or international agency to stabilize price. There is probably scope for further research into the nature of price formation where cash and futures markets exist in parallel, but even more should be done to assess the impact of such stabilization operations on other participants in the market. Will they scare away hedgers or speculators? Will they attract speculation of the wrong sort: that designed to profit solely from the eventual exhaustion of the agency's resources, whether of cash at the bottom of the market or of commodity at the top?

My misgivings go beyond simply the capacity of officials to stabilize prices. I see a greater danger. It is widely recognized that the public sector has a role, however modest, in the regulation of commodity trading. This role must be exercised in cooperation with the exchanges themselves and with absolute impartiality towards all who trade on the markets concerned. Such regulation is quite incompatible with government operations on such markets designed to influence prices and by implication to favor one group of market participants against others. I would question whether this conflict can ever be solved by simply keeping the regulatory and the stabilization agencies at arms length since both derive their authority from the same source.

If the prospects for stabilization of prices through intervention in the futures markets look slight, prospects for primary producing nations to stabilize their incomes by using futures markets may offer more hope. We should, however, be aware of the background against which the primary producers see the marketing process as a whole. An item under this title has been on the agenda of the United Nations Conference on Trade and Development (UNCTAD) Committee on Commodities since the early 1970s, but progress generally has been slow. Although the intention was to study a fairly wide range of commodities by the time of UNCTAD IV in Nairobi last year, only three studies had been completed: cocoa, bananas, and hides and skins. Both the London and New York futures markets came under attack in the cocoa study for permitting excessive speculation to destabilize prices to the detriment of the primary producers. The developed countries have denied these charges, but they have failed to convince the primary producers. The same criticism of futures markets reappeared, and remained unresolved, as a sideline to the Conference on International Economic Cooperation North-South dialogue in Paris this year, and no doubt more will be heard of it.

Even if one does not accept the primary producers' mistrust of the futures market, one can perhaps understand their fear of the speculator's role. Speculation does involve the employment of wealth that is surplus to that necessarily set aside to ensure a comfortable and secure standard of living in societies where that standard is already very much higher than in many primary producing countries. The belief that such speculators are making vast profits at the expense of the impoverished producer—a view that has also been expressed from time to time in the legislatures of both the United States and Britain—has emotive overtones that simply cannot be ignored.

However, a role exists for further studies and education not only of the role of speculation but also how futures trading can help the primary producers. Before considering this, there is one more question to try to clarify, and here I am inclined to take issue with Gardner. I accept his proof that options trading can be used to stabilize a producer's income, but I believe that the producer really wants to maximize, not stabilize, his commodity income. Where the producer is largely or totally dependent on the income from that one source, however, he may recognize the need

Ben W. Gunn is with the Economic Intelligence Department, Bank of England, London.

to hedge, to sacrifice some of the potential profit in times of high prices to ensure a minimum subsistence income when prices are low. Even then he will not think in terms of stabilizing but in terms of the price he pays for the amount of security of income he needs.

Powers offers alternative strategies to the primary producers, either to operate on the existing markets in the developed world or to set up markets of their own. Both solutions present difficulties.

To turn to the possibility of new markets in the countries of origin, I find myself in substantial agreement with the six criteria Powers has laid down. I would add that it is not merely the need for adequate financial resources but the willingness to apply those resources to support futures exchanges in the face of competing and urgent priorities. The supply of speculation, too, may cause difficulty. If nonresident, it will demand free access to foreign exchange reserves, while if resident it may demand a distribution of wealth that is unacceptable socially in a relatively poor country.

My main doubts, however, stem from the fact that placing the futures market in the country of origin does nothing to stabilize that country's foreign exchange earnings, apart from the quite modest inflow of commissions that is generated. The flows associated with nonresident speculation and hedging by the overseas buyer are quite unpredictable. This places net foreign exchange earnings firmly in the hands of nonresidents. In a recent investigation into the United Kingdom's foreign exchange earnings from commodity trading published in the Bank of England *Bulletin* for March 1977, this was observed to be true for Britain also. The cash flow into or out of Britain depended entirely on the trading actions of nonresident users of U.K. futures markets and not upon the activities of U.K. traders. While not ruling out further study into establishing futures exchanges in primary producing nations (indeed, the producers themselves may well request it), I am not, at this stage, optimistic as to the outcome.

We have, therefore, to examine whether primary producers should operate on the existing markets. I think Powers has done us all a service in documenting the limited use the producers have made so far of markets in the United States. While we do not have the same statistical base from which to work, I am sure that the experience of the London markets is no different. The question now is whether we can—or should—encourage the producers to expand their use of existing futures markets. If I conclude by pointing to still further obstacles to be overcome, it is in the hope that prompt attention to the problem will arrive at solutions because it is in this field that I think that further research, study, and discussion can offer the most positive results.

From the primary producers we will be asking a fundamental change of attitude. The whole emphasis in international commodity negotiations has been toward the administration and suppression of the price mechanism in the interest of stabilization of incomes. The developing countries are not alone in this. Many countries in the world have done the same for their farming communities. In suggesting that many producing countries might benefit from more active use of futures markets, however, we are saying that they will have to learn to trade their commodities. This may require the transfer of responsibility for important segments of their economies from price administrators to commodity trading experts. Even if the latter are directly answerable to government, resistance to change and especially to change so controversial as this is only to be expected and will only be overcome if the advantages of an active trading policy can be clearly demonstrated.

Inviting the primary producers onto the markets will bring about change there, too. It is unlikely that such participation will come from individual producers within countries. In practice, such trading will have to be in the hands of governments or state trading agencies, who by their sheer size may carry considerable weight in the markets, even to the extent of being buyers or sellers of last resort. There is nothing to fear in this if the primary producers approach the market responsibly. We have seen such steady trading from London commercial firms with just as much potential to overwhelm the market, but a high degree of technical trading skill and sensitivity is called for. I should add that there is little the regulatory process can do to help. Any attempt to use the regulatory mechanism as a correction automatically raises international political issues between the two governments, which, if the regulation has the effect of restraining a rise in price, may also have overtones of exploitation.

To sum up, all this sounds rather negative, but my experience with commodity trading has convinced me that there are many prob-

lems to be resolved before we can be certain that existing markets can offer to the primary producers a workable and worthwhile alternative to the policies they are at present pursuing. Nevertheless, I believe that this is the line we should be following and the one that without excluding further study of alternatives should form the keynote of discussion today and the starting point for research that will spread far beyond the confines of this meeting.

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Discussion

Allen B. Paul

These are two thoughtful papers. I have three comments on each.

Powers and Tosini show that Latin American traders' share of coffee futures recently had reached 25% of the total on the long side (shades of 1953?). A Federal Trade Commission (FTC) study found that in December 1953 a few Brazilian long accounts in N.Y. futures increased from 856 to 1,846 contracts, or one-half the open interest—largely accumulated in one week beginning 2 December when Brazil announced an increase in the loan rate from 1,200 to 1,500 cruzeiros per bag, after the hard July freeze. Such trading smacked of unfair advantage.

The FTC suggested imposing position limits. This advice was never followed, and it is just as well. It would not prevent anyone from making large forward cash commitments, which in turn could be laid off against futures. As Powers and Tosini argue, U.S. markets cannot readily be insulated from manipulative actions from abroad, whether by individuals, groups, or governments. But other people's information can probably be improved in order to reduce the power of some to manipulate or otherwise distort prices. More disclosure of changes in large cash and futures positions is needed if the game is to be competitive.

The relation of financial institutions to development is one of the grand themes of economics. Does financial development lead or follow growth of output? Goldsmith concludes that there is evidence on both sides. Powers and Tosini show the route to capital accumulation via futures trading to promote local savings and investment, attract foreign capital, and develop banking services. They list conditions in less developed countries essential to successful functioning of futures. To test these ideas, one might study India's experience with many small inland commodity exchanges.

Hicks teaches a larger perspective. Over the centuries, man has bettered his lot through the rise of markets, which implies the rise of a class of people who specialize upon trade. The conditions for the rise of markets are best at certain geographic nodes (historically, the city-state at the water's edge); and when this happens, it sets in motion the mercantilization of more and more of economic life. Institutions first arise to create widely acceptable money and credit, then to create more tradable rights in commodities and finally more tradable rights in land and labor. This evolution of the ideas and instruments of property that can be readily bought and sold by anyone who has the means works its way back into the hinterland and ultimately brings about great changes. Mercantile institutions spread slowly, much more slowly than most technology, but spread they do. The Powers and Tosini paper suggests that there are large educational opportunities to guide policy into fruitful channels not only in respect to futures trading but in respect to all institutions of trade if we were only equal to the task.

On buffer stocks, Powers and Tosini suggest that governmental programs, however handled, are largely incompatible with futures trading. I agree. Thus, it is an illusion to think that, in practice, the government can enter into futures trading to influence the carrying of stocks without also sapping its usefulness in allocating resources.

Futures trading is but one entity in the conflict between state and private decision making. We are a long way from settling such issues on a scientific basis. We need solid empirical studies of program alternatives, including the benefits of preserving the institutions of trade, e.g., what would be the effect on the world economy if there were no Chicago Board of Trade, or its equivalent, with which to price grain dealings within and between countries, state-planned or otherwise?

This is a fitting place to turn to Gardner's paper on commodity options. Such trading now is banned for major farm products. He makes a plausible case for their use to stabilize net income from a given crop whenever its

Allen B. Paul is an economist with the Economic Research Service, U.S. Department of Agriculture.

prices and yields are uncertain and negatively correlated.

This gets to the heart of a farmer's problem in using futures. Gardner shows how options could be used to supplement forward sales of a safe part of his expected crop; he also shows how options might replace futures altogether. But, conceptually, the same problem could be met by strategic use of futures—e.g., sell the normal output forward and then buy in one-third of this quantity if the futures price were to rise by the cost of an option; later, sell this quantity forward if the futures price were to drop to the original level. Option trading may cost less if the specialized intermediaries deal in volume, and they may offer less lumpy units. Also, market orders are uncertain of execution at a selected price. But currently the costs of eight-month options in London trading in coffee and sugar futures are about 20% of the price of futures, and options are thinly traded.

Options pose some social problems. While historically they have arisen in response to a genuine business need, like that shown by active trading in call options in the seventeenth century on the Amsterdam bourse for herring and other commodities that were to arrive by ship in uncertain quantities, option trading also has been outlawed from time to time. Undoubtedly reasons were not always well grounded in theorems of economic welfare. Genuine problems arise because in modern times option trading has been conducted in conjunction with highly organized futures machinery, and it has been used to cover increases or decreases in large futures positions. Mehl seems to suggest that the big option writers had manipulated futures prices in their favor when the exercise date had arrived. An important question at issue is whether regulation of option trading could be effective in preventing such manipulation and at what cost.

Gardner's analysis of government price supports as a put option freely given to farmers is apt. His suggestion that a government commodity reserve could be operated by granting such a put option, conditional on the farmer's granting the government a call option at twice the loan (put) price, is intriguing. But there might be nonperformance by some farmers because of low yields. A problem would arise only where there are not "safe" levels to create a call option against.

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Discussion

Anne E. Peck

From the figures on foreign participation in futures markets, especially those for the less developed countries (LDC's), provided by Powers and Tosini, it appears that foreign traders rank only marginally above farmers in their direct interest in futures markets. The comparison is apt, for most foreign participation, and again especially for the LDC's, would be as producers, presumably, rather than as consumers or processors. Thus, there is a strong link between the papers presented today. The link lies in the producer and his seeming lack of interest in forward pricing.

Futures markets provide a market mechanism to deal with price level risk in a roughly symmetric fashion. This may not be their most important function,[1] but it is clearly one of their functions. By symmetric, I mean that, once a position has been taken, price changes in either direction affect profits or losses in an equal way. Profits or losses from an options position, on the other hand, are distributed asymmetrically with respect to the underlying instrument's (commodity or futures contract) price movements.

In this context, Gardner has developed a case in favor of options markets using the producer as his example. One reason that producers do not use futures markets or forward contracting to forward price their output may well be that their price risks are distributed asymmetrically. For example, suppose that at planting time, the market is somewhere near equilibrium, and the farmer plants accordingly. He expects normal yields, though realizes that he may get somewhat better or worse than normal results depending on rains and growing season temperatures. He also realizes that there is a possibility for disaster, for example, a corn blight or a drought. In this view, then, his basic production risks are not symmetric. Additionally, assuming a price inelastic demand, his income will be significantly higher in the high price years than in the normal-type years.

Perhaps, then, the reason farmers do not forward price with futures (or forward cash contracts) is that they would thereby not be able to take advantage of those bad yield/good price years. An options market, however, would permit the farmer to deal more effectively with exactly this type of risk, as Gardner's illustrations make clear. However, basically equivalent results can be obtained with the combination of a short futures position with an appropriately placed stop-loss order.[2] Since this is a possible trading strategy, why are farmers not trading? Or, more pointedly perhaps, if producers do not participate in options trading (assuming it is permitted on an experimental basis), is that grounds for deciding it is serving no economic purpose?

The other producer group of interest in this session are the foreign producers. I can only agree with Powers and Tosini that there are a variety of special legal reasons why futures trading by these groups (especially if it would be by state-owned marketing boards) in domestic markets should be carefully monitored. However, their presence or absence in the market seems to me not to matter when considering their fundamental influence on the market. For example, a freeze that damages the coffee crop in Brazil will have price effects in New York futures whether or not the Brazilians are trading there. Alternatively, a severe shortfall in Russian wheat production influences prices only if the Russian decide to enter the world market to make up the deficit. Whether they make that intention known directly through cash transactions or "indi-

Anne E. Peck is an assistant professor, Food Research Institute, Stanford University.

[1] The evidence suggests that the most important function of futures markets is in facilitating the intertemporal storage of commodities. The largest users of these markets are inventory holders, and they hedge to earn a profit from basis changes, not to avoid risks. On this point, see Working and Gray.

[2] A cheaper alternative would be to forward contract with the local elevator, simultaneously placing an order to buy futures at a specified price above the current futures price. In either case, the producer would benefit from the occasional large changes upwards in the underlying price level during any specific growing season. Determining the optimal prices to place the stop-loss order or the buy order is roughly equivalent to determining the value of an option.

rectly" through futures purchases does not really matter in the ultimate price effect.

Given the market statistics on foreign use of U.S. futures markets, one might wonder if there is any chance that new, "local" futures exchanges would survive, even if established. The statistics are not encouraging. It is likely, however, that U.S.-based futures markets are of little use to large segments of potential hedgers because of very unpredictable basis patterns. Thus, extensive commercial inventory hedging is simply not feasible in U.S. markets for foreign merchants. Regional exchanges would alleviate this problem to a great extent. Interexchange arbitrage would be another source of potential monetary benefits to the countries establishing the exchanges.[3]

Finally, both papers consider the price and income stabilization potentials with these forms of markets. Gardner states that "A major rationale for price support programs would disappear if a well-functioning market in put options existed." In any one year, farmers' purchase of a put option clearly would be equivalent to the effect of a loan program. However, exercise prices of options would likely vary as much as the underlying commodity prices from year to year.[4] Income and/or price stabilization similar to that provided by the loan program with its relatively constant (from year to year) loan prices would be impossible. Alternatively, suppose a constant year-to-year exercise price is established. In this case, the farmer would pay substantially for his put option in the low price years, and the net price for his production would be no different than if he had simply marketed it at the lower cash prices. Income (price) stabilization similar to the loan program is not possible in either case.

Powers and Tosini, on the other hand, focus their discussion on the proposals to stabilize cash prices with a futures fund rather than a buffer stock fund. In particular, they note it is likely that a futures fund, generally net long, would need to stand for delivery of commodities, thereby not in fact being able to avoid the accumulation of the commodity. In fact, it is more than just "likely" that these deliveries would have to occur. The basic proposal to trade futures instead of the cash commodity relies upon there being a close relationship between cash and futures prices. Indeed, for most major markets there is a close relationship. This relationship, however, exists only because of the threat and/or possibility of delivery. If a government fund, trading large quantities of futures, did not stand for delivery on its positions, the connection between cash and futures prices would dissolve, and the presumed price effects of government futures trading would not be transmitted to the cash prices.[5] Therefore, the purchase of futures could only be a temporary substitute for the accumulation of cash stocks, not an alternative method of stabilizing price.

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[3] An analysis of this kind of arbitrage is Dominguez's study of the London and New York cocoa markets.

[4] It makes no difference whether the option is on futures contracts or on the cash commodity, since futures prices are generally as variable as cash prices (Tomek and Gray). Since these prices do vary between years, it is likely that the exercise prices would also vary.

[5] An analysis of this and other effects of the government's trading of futures contracts is available in Peck's study of the Federal Farm Board's experiences.

Assessing Public Policies and Programs: Equity Considerations
(Kenneth L. Deavers, Economic Research Service, USDA, Chairperson)

Sociopsychological Measures of Quality of Rural Life: A Proxy for Measuring the Marginal Utility of Income

Wilmer M. Harper and Luther G. Tweeten

Economics has been defined as the science of allocating scarce means among competing ends. Ultimate ends to be achieved may be defined as well-being, satisfaction, utility, or quality of life. It has become fashionable to divaricate economics into dimensions of efficiency and equity. Defined as increasing the size of the "pie" of goods and services, efficiency has received the lion's share of attention by economists; its study has been viewed as objective, precise, and respectable.

Economists have relied heavily on perfect competition as a norm of efficiency, but perfect competition results only in a Pareto optimum. Using the Edgeworth Box as an example, two individuals or groups can be at a Pareto optimum on a contract curve, yet one individual or group can be in misery from starvation while the other individual or group can be satiated with goods and services. To move along the contract curve to a point of global welfare maximization requires knowledge of the marginal utility of additional goods and services (income). Utility is maximized at the point where marginal utility of income is equalized. Suggestions for such movement have been eschewed by positive economists in part because subjective, normative, interpersonal comparisons of utility were required and in part because, even if accurate estimates of marginal utility were unavailable, a normative judgment is implied that such movement is appropriate.

It is time to begin merging equity and efficiency in economic science, the nexus being the marginal utility of income. Given that economics is concerned with increasing well-being of people, the study of conventional measures of efficiency is neither objective nor precise because it conveniently assumes away too much by employing the premise that the marginal utility of income is equal for all income levels and all people. Neither is it appropriate to label the study of equity as unsuitably subjective and imprecise in view of advances in methodology that can provide useful comparisons of quality of life among populations defined by income, age, education, etc. Although methods for estimating marginal utility may yet be too imprecise to make interpersonal comparisons of the marginal utility of income, the methodology appears to be sufficiently advanced to make useful intergroup comparisons of utility for formulating public policies that impact unevenly on different groups.

If the marginal utility of income is less for gainers than for losers, it is possible that some public programs implemented on the basis of favorable conventional benefit-cost (B-C) ratios may in fact reduce well-being. To promote a nexus between equity and efficiency, an efficacious start is to replace the concept of economic efficiency implicit in benefit per unit of cost (B-C ratio) with the concept of social efficiency defined as satisfaction per unit of sacrifice. Social efficiency is similar in concept to economic efficiency except that dollar benefits are weighted by marginal utilities among gainers to indicate satisfaction, and dollar costs are weighted by marginal utilities among those paying the cost to arrive at total sacrifice.

Wilmer M. Harper is with the Department of Agricultural Economics, New Mexico State University, Las Cruces, and Luther G. Tweeten is Regents professor, Department of Agricultural Economics, Oklahoma State University.

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One goal of public policy is to fund projects with greatest social efficiency. Provision of satisfaction-sacrifice (S-S) ratios by no means rids the policy maker of the need to make judgments. The S-S ratio (or, alternatively, net social benefit defined as satisfaction minus sacrifice) from a project is but one of several positivistic pieces of information. The decision to allocate funds requires that the policy maker balance the S-S ratio against other information such as the outcome variation, the ethical soundness, and the political feasibility of increased well-being for society as a whole but requiring sacrifice by some members of society.

An advantage of the S-S ratio over the B-C ratio is its ability to measure the social efficiency of a wide range of programs including transfer payments. If the marginal utility of income is sufficiently great for low versus high income groups, greater social efficiency gains (based on the S-S ratio) may be obtained by redistribution of income than by some investment projects with conventional B-C ratios greater than 1.0.

If economics is indeed the science of allocating scarce resources among competing ends to improve well-being of society, social efficiency measures seem appropriate. This study shows one method of developing weights for benefits and costs among income groups for use in S-S analysis. The perceived quality of life index (QLI) is put forth as a measure of individual satisfaction and a proxy measure for utility.

Given knowledge of income flow over a period of time, economic theory holds that the rational consumption unit will choose that combination of goods and services that maximizes the satisfaction derived from the income stream. Well-being is assumed to be enhanced by having more options—greater income increases the options for purchasing goods and services or accumulating wealth that contributes to power and prestige. Given the basic economic assumption that more is preferred to less and the fact that income of the individual is finite, perceived quality of life is constrained by income. It follows that the quality of life that the individual perceives is, at least in part, a function of income.

Since Srole's development of a social indicator scale for anomie, social scientists have attempted to measure the relationship between social indicators and income. An inverse or negative relationship has been demonstrated between anomie and level of income (McDill, Mier and Bell, Bell, Bullough). A positive relationship between income and self-esteem has been established (Crain and Weisman; Heiss and Owens; Yancy, Rigsby and McCarthy), but the aggregation of income into too few segments (e.g., high and low) precludes determination of the rate of change in self-esteem as income varies. Scales measuring "level of happiness" or "life satisfaction" perceived by the individual have been found to have a positive relationship with income (Easterlin, Bradburn and Caplovitz).

The Rural Income Maintenance Experiment (RIME) conducted in Iowa and North Carolina during 1969–72 was a major effort "to test the behavioral consequences of a universal income-conditioned cash transfer program" (Bawden and Harrar, p. 1). The extensive sociopsychological data collected as part of the experiment included items that were modifications and adaptations of established social indicator scales. These items and the accompanying income and demographic items form the data base for this analysis. Data on attitudes were complete only for quarters 2 and 10 of RIME (Bawden and Harrar).

The objective of this paper is to construct a measure of individual perceived quality of life and to relate this measure, using ordinary least squares, to income, age, education, and other explanatory variables. Data were available for both household head and spouse, but taken as separate data sets, each group produced statistical results less satisfactory than those from the pooled data set reported herein. The coefficient for a dummy variable for spouse inserted into the general model was not significant at the 0.05 probability level. The family was taken as the relevant data set for QLI development and analysis. When logically consistent, independent variables were aggregated into family units and related to attitudes of the head and spouse.

QLI Construction and Analytic Framework

The quality of life index (QLI) is conceptualized as the weighted summation of three sociopsychological subindices: alienation (A), worry (W), and self-esteem (SE). The subindices were constructed from established social indicator scales. To verify the a priori conceptual grouping of the scale components into the subindices, principal axis factor analysis was

performed on the entire set of scale items with the number of factors restricted to three—the number of subindices. The resulting loadings of individual items upon the three factors substantiated the grouping of the scales into the proposed subindices.

Factor analysis was also used to identify factors (hypothetical constructs) that explain the variation observed within the individual scales. The following criteria were used to determine the maximum number of factors incorporated into each scale: the factors retained had eigenvalues greater than or equal to one, and/or the addition of another factor would result in the grouping of the scale items into a less plausible configuration of the scale items. To assure internal consistency and a QLI directly related to positive and negative perceptions, the factor loadings for negative construct factors within each scale were "reflected" by changing the algebraic signs. Individual responses to each item were standardized by dividing deviations from the mean item score by the standard deviation. Individual scale values were then calculated by the following functional relationship:

$$M_i = \sum_{k=1}^{m} E_k\left(\sum_{j=1}^{n} f_{kj}R_{ij}\right),$$

where M_i is the scale value for the ith individual, m is the number of factors extracted for the scale, n is the number of items in the jth scale, E_k is the eigenvalue for the kth factor, f_{kj} is the factor loading for the jth item on the kth factor, and R_{ij} is the standardized response of the ith individual to the jth item on the scale. The subindices of the QLI were calculated as

$$A_i = An_i + P_i + NA_i$$

and

$$SE_i = SS_i + LS_i + PA_i,$$

where An is anomie scale ($m = 1$), P is powerlessness scale ($m = 1$), NA is negative affect scale ($m = 2$), SS is self-satisfaction scale ($m = 2$), LS is life satisfaction scale ($m = 2$), PA is positive affect scale ($m = 1$), all for the ith individual. The worry subindex (W) consisted of only one scale with $m = 1$.

The final step in the QLI construction was the weighted summation of the three subindices. In the verification of the a priori subindex composition, each of the three factors received the loadings of the majority of the items of one of the subindices. The results of this analysis were used for the final weighting, and QLI_i was calculated as

$$QLI_i = E_aA_i + E_wW_i + E_{se}SE_i,$$

where E_a, E_w, and E_{se} are, respectively, the eigenvalues of the factor containing the majority of the items making up that subindex.

Theoretical QLI Model

The nuclear model for the QLI analysis was judged a priori to be of the following form:

$$QLI_i = f(Y^*_i, ED_i, AGE_i, N_i, L_i, R_i, S_i, PERFARMY_i, NW_i, QTR, T_i, E_i),$$

where QLI is the quality of life index. The independent variables are: Y^* is the expected net income in current quarter, including transfer payments, of the family unit; ED is the educational level (last grade completed) (Katona, Yuchtman); AGE is the age (Katona); N is the number of individuals (Smith and Haythorn); L is the geographical location of the residence of the family unit ($L = 1$ if Iowa; $L = 0$ if North Carolina); R is the race (Yancy, Rigsby, and McCarthy; Heiss and Owens; Tweeten and Lu); S is the sex; $PERFARMY$ is the farm income/total income ratio for the family unit (Tweeten and Lu); NW is the net worth of the family unit (Ackley); QTR is the time variable ($QTR = 0$ for quarter 2; $QTR = 1$ for quarter 10); T is the negative income tax treatment of the family unit; E is the error term, and i subscript represents the ith individual or unit. Interaction among the independent variables was also considered theoretically germane to the model. Four algebraic forms were initially considered: logarithm, square root, quadratic, and cubic.

Empirical QLI Model

Criteria for selecting a functional form were R^2, coefficient signs, and size of t-ratios. The quadratic form of the QLI model was selected, and certain of the theoretically admissible variables were rejected from the model on the basis of statistically insignificant coefficients (see table 1). The nine independent variables account for 82% of the variation in QLI, and each coefficient is significant at the 0.04 probability level or better.

In the empirical model, education (ED^2) is positively related to the individual QLI, but for any given level of education, increasing

Table 1. Ordinary Least Squares Estimates Relating QLI to Selected Variables

Variable	Coefficient	*t*-Ratio	Standardized Coefficient
Intercept	−236.14916910	−6.17425	—
Y^*	0.01923246	5.80810	0.13045
Y^{*2}	−0.00000094	−3.89588	−0.08238
ED^2	0.99464418	5.77013	0.15973
PERFARMY	31.15025446	3.02201	0.03336
L	26.34498185	3.49683	0.04108
AGE	4.28721617	2.71663	0.17013
AGE^2	−0.03179832	−2.10702	−0.11707
AGEED	−0.19949018	−3.44485	−0.09170
QTR	−563.33453861	−91.00945	−0.89993

N = 2,014 R^2 = 0.82
$\overline{QLI}$ = 330.35[a] s = 134.5683
$\overline{Y^*}$ = $2,193.41 per quarter $\overline{PERFARMY}$ = 0.02 (proportion)
$\overline{ED}$ = 9.62 years $\overline{AGE}$ = 43.21 years

[a] The coefficients of the independent variables are invariant to addition of a constant to the scale. Negative predicted values may be avoided by an arbitrary addition to the scale; adding a constant would affect only the intercept.

age diminishes the contribution of education. *AGE* initially exhibits a positive contribution to QLI, reaches a maximum, and declines thereafter. Based upon average level of education (see table 1), the contribution of *AGE* to QLI reaches a maximum at 39.43 years and becomes 0 at 78.87 years. The marginal contribution of *AGE* to QLI is linear and declines throughout. Interaction of age with education (*AGEED*) causes a change in the responses of QLI to age with each level of education. The positive relationship of location (*L*) to the QLI may arise from superior public services and other "environmental" factors in Iowa. The possibility that income contributes to the variation explained by *L* is discussed later with the income specific analysis.

A preference within the study group for farm derived income is shown by *PERFARMY*. The data do not permit a determination of the reason for this preference, but two potential sources are immediately apparent. Individuals may experience a positive influence from farming as a way of life; underreporting farm income may also make a dollar of reported farm income preferable to a dollar of nonfarm income. The time trend variable (*QTR*) accounts for considerable observed variation in QLI, but without additional observations for the QLI scale items, the data are not sufficient for an evaluation of the source of the variation explained by *QTR*. The "washing out" of an experimental payments effect over time, a decline in a "Hawthorne" or participation effect, or changes in the social environment and national mood of the United States are all potential sources of the observed *QTR* variation.

The failure of the theoretically admissible *NW* variable to enter the model may be due to inadequate data on net worth coupled with the fact that a large portion of the sample consists of low income individuals with little net worth.

Based upon an analysis of the general model containing Y_t and Y_{t-1} (t is quarter) as separate variables, income was aggregated into expected income (Y^*). Coefficients for the linear terms Y_t and Y_{t-1} were significant at the 0.05 probability level, but the coefficient for Y_{t-1} was much smaller. Y^* was calculated as

$$Y^* = \frac{b_{yt}}{b_{yt} + b_{yt-1}} Y_t + \frac{b_{yt-1}}{b_{yt} + b_{yt-1}} Y_{t-1}.$$

The decline in the size of the coefficients from Y_t (0.002298) to Y_{t-1} (0.001236) indicates that Y^* should not be seriously biased by the lack of additional lagged income periods. QLI reaches a maximum (marginal QLI reaches zero) at $40,942 of expected income Y^* per year, which is outside the range of the data; the point must, therefore, be interpreted with caution. The marginal contribution of Y^* is linear and declines throughout.

Income Related Hypotheses

Having established a general QLI model in which Y^* is one of the variables, we now appraise in more detail the specific impact of income on the QLI.

The relative versus absolute hypothesis tests the proposition that the variation observed in the QLI depends upon the relative as well as the absolute level of income. A dummy variable *PI* ($PI = 1$ if $Y^* > \bar{Y}^*$) was used to separate the regional data sets into subsets, where Y^* is above the mean ($\bar{Y}^*$) or less than or equal to the mean of the respective state sample. The relevant test statistics for *PI* are coefficient, 5.8514, and *t*-ratio, 0.585.

Given the small *t* for the coefficient of *PI*, the Chow test was used to test the structural stability of two equations estimated with data for individuals respectively above and below the mean of Y^*. The *F*-statistic (2.20) rejects at the 0.05 probability level the null hypothesis that the regression coefficients estimated by the respective subsets belong to the same structure, and the two structures are inferred to be different at the chosen level of significance. The difference need not arise from different responses to income, however. The regression coefficients 0.0165 (Y^*) and -0.0000008 (Y^{*2}) for data set $Y^* > \bar{Y}^*$ and 0.00226 (Y^*) and -0.0000011 (Y^{*2}) for data set $Y^* \leq \bar{Y}^*$ suggest that the marginal response of QLI with respect to Y^* is greater for the subset $Y^* \leq \bar{Y}^*$ than for the subset $Y^* > \bar{Y}^*$ over all relevant ranges of Y^*. A crude test for difference between the paired coefficients is $t = (\hat{b} - c)/s_b$, where *c* is the coefficient of the linear (squared) income variable and *b* is the corresponding coefficient of the linear (squared) variable in the equation of income above (below) the mean. The difference is significant at the 0.10 probability level for only the coefficient *c* of linear term Y^* of the subset $Y^* > \bar{Y}^*$.

The coefficient of the variable *L* is highly significant. *L* may also measure a part of the variation in QLI arising from a relative income phenomenon. If persons in North Carolina and Iowa judge their relative position based on a national rather than local perspective, the coefficient of *L* could indicate a lower QLI experienced by persons in North Carolina as they perceive their relative deprivation. The place of relative versus absolute income in determining the quality of life needs further consideration when more comprehensive data become available.

The income irreversibility hypothesis is that the marginal response of QLI is greater for falling income than for rising income. Two methods were used to test this hypothesis. First, the income variable was segmented into rising and falling components. No evidence was found to support the hypothesis that the marginal response of QLI with respect to Y^* is greater for falling than for rising income. Second, the Chow test was used to evaluate the structural stability of the QLI model with the data set subdivided into observations for respondents whose income increased and for respondents whose income decreased during the past quarter. The *F*-statistic (1.28) failed to reject at the 0.05 probability level the null hypothesis that the regression coefficients estimated by the respective subsets belong to the same structure. In estimating the impact of income on the quality of life, differentiating between rising and falling income does not appear to be necessary—the QLI index appears to be reversible.

The earned-unearned income hypothesis tests the proposition that earned income (Y^*_e) and unearned income (Y^*_{tr}) have different influences on QLI. The income variable (Y^*) was segmented (other variables the same as in table 1) with the results given in table 2. The coefficients indicate that the marginal QLI response to Y^*_{tr} is initially greater than to Y^*_e, but it falls more rapidly for Y^*_{tr} and reaches zero at a much lower level than for Y^*_e.

Separate regressions taking the model with Y^*_e and Y^*_{tr} as the unrestricted model and the model with Y^* as the restricted model failed to yield an *F*-statistic (1.25) significant at the 0.10 probability level.

In a test of the equality of the paired coefficients; (H_0: $B_{ye} = B_{ytr}$), the analysis failed to reject H_0 at the 0.05 probability level for both pairs of coefficients, but the analysis rejected H_0 at the 0.10 probability level for the squared terms. In short, the results provide modest and mixed support for the proposition that QLI responds differently to earned than to unearned income.

Implications and Potential Uses

The QLI function and the accompanying hypotheses of this analysis apply to some of the central issues of economic policy. These results, if substantiated by further experimentation, have profound implications for equity issues and suggest substantial welfare gains from a more nearly even distribution of income. Supplemented by findings extended to other geographic, temporal, and income conditions, results such as those shown above

Table 2. Estimates for Earned and Unearned Income

Variable	Coefficient	*t*-Ratio
Y^*_e	0.01647140	4.105
Y^{*2}_e	−0.00000095	−2.978
Y^*_{tr}	0.02452665	3.507
Y^{*2}_{tr}	−0.00000396	−2.242

would allow the computation of a more nearly optimal distribution of income. These results can provide a foundation for revision of income tax scheduled to provide equal marginal sacrifice or to redistribute income (see Harper). Benefit-cost ratios for public projects could be constructed by weighting benefits and costs among income groups according to the marginal impact on quality of life. The QLI results could enable the determination of an appropriate mix of transfer payments versus earnings-generating programs to maximize QLI. Findings can also be used to compute welfare losses from an unstable economy as well as benefits from programs to reduce instability. Given the declining marginal response of QLI to income, a greater quality of life may be derived from a given stable income than from the same income received on the average but with variability. Education appears to have an impact on quality of life independent of income; this finding could alter the procedures for computing returns to schooling. Amplification of the data base to additional geographic areas, income levels, sectors, and time periods should be accompanied by a reconsideration of the variables rejected from the general model.

The QLI model of this analysis reflects the environmental aspects of quality of life only as they influence individual responses. It would a priori appear that a more adequate explanation of quality of life would entail a larger set of independent variables including the institutional structure of the environment.

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Distributional Equity of the Food Stamp Program

Philip L. Martin and Sylvia Lane

Under the current Food Stamp Program, participating low income households obtain stamps usable for the purchase of any food in cooperating retail outlets (USDA 1976b).[1] The program was made available to counties wishing to adopt it under the Food Stamp Act of 1964 (U.S. Congress, Senate 1976b). Food stamp and food distribution programs operated simultaneously as state-administered programs throughout the 1960s. By 1970, Food Stamp Program outlays amounted to $550 million (USDA 1976a). But between 1970 and 1976, standards of eligibility became nationally uniform and benefits were liberalized (1971); the Food Distribution Program was almost entirely phased out; the Food Stamp Program expanded to encompass participation by every county in the nation and by its territories (USDA 1975b); the number of Food Stamp Program participants quadrupled, and Food Stamp Program outlays increased over 950% to $5.9 billion (U.S. Congress, Senate 1976b; USDA 1976a; U.S. Congress, Senate 1976a). This expansion has been characterized as the single most important welfare change in America since the passage of the Social Security Act of 1935 (Nathan). Nonetheless, the Food and Nutrition Service of the U.S. Department of Agriculture estimates only about 60% of those eligible in the period of a month and 76% of those eligible in the course of a year elect to participate in the program (USDA 1975b, U.S. General Accounting Office).

Past studies indicate that those eligible may not participate because of ignorance, program costs to recipients, lack of income to purchase stamps, or the problem of earmarking income for food or because local attitudes discourage participation (U.S. Congress, Senate 1975a; U.S. General Accounting Office; Lane). Food Stamp Program participation varies across defined geographic and demographic cohorts, with urban eligibles more likely to participate than those in rural areas, younger persons more likely to participate than older persons, whites more than nonwhites, and larger families more than smaller families (USDA 1975a).

The Food Stamp Program is an "entitlement" program, i.e., the program promulgates eligibility criteria and a formula for calculating benefits but not a fixed expenditure level. Therefore, total program outlays accruing to different geographic areas depend on the level of benefits (uniform under the Food Stamp Program, depending only on family income and family size), the distribution of eligible beneficiaries, and the extent to which eligible persons elect to participate in the program.

In this paper determinants of county-level Food Stamp Program outlays per capita and per poor person in 1975 are assessed in light of county characteristics. The term "distributional equity," as used in this paper, implies that the Food Stamp Program should operate to assure that per capita county-level benefits vary only with those characteristics affecting program eligibility, viz., family size, income, and unemployment indicators, and that per poor person outlays should fall within a narrow range across classes of counties aligned along an urban-rural spectrum. The 3,097 U.S. counties are arrayed along a nine-category rural-urban continuum, and county-level outlay data are regressed against county characteristics data for 1970. County characteristics data are available on a national basis only in census years, forcing the use of 1968 and 1970 independent variable data to explain more recent outlay patterns. Although differential changes between and within rural and urban

Philip L. Martin is an assistant professor and Sylvia Lane is a professor in the Department of Agricultural Economics, University of California, Davis.

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[1] A Food Stamp Program was operative from 1939 through 1943. Pilot programs were in existence in 1959 and federally mandated in 1961. Presently, food stamps may also be used to pay for meals furnished by some nonprofit meal delivery services, meals at communal dining facilities for the elderly, plants and seeds to grow food for the household's own use, and hunting and fishing equipment for qualifying Indians and Eskimos.

areas could limit the model's reliability, the relative position of counties with respect to the variables considered appears relatively stable.

In the following sections, salient features of the Food Stamp Program will be reviewed and the regression model and data sources described. The results of the regression analysis and their implications are reviewed. The summary, conclusions, and recommendations are in the final section.

The Food Stamp Program

To be eligible for benefits under the Food Stamp Program, a household must have cooking facilities, be unable to buy a "nutritionally adequate diet" (as specified in the USDA's thrifty food plan) with approximately 30% of its monthly net income, have less than $1,500 in liquid assets ($3,000 if a household member is over 60), and all able-bodied household members must register for and accept suitable employment. Public assistance and supplemental security income recipients (except in Massachusetts) are automatically eligible. Eligibility standards are uniform across the nation (USDA 1976b).

Food stamps cost recipients from 0 to 86% of their face value, the cost of the stamps being determined by family size and the recipient's income after allowable deductions. Deductions averaged $56.50 per household in 1975 (USDA 1975b). The purchase requirement varies between 0 and 30% of income. On average, Food Stamp Program recipients pay between 40¢ and 45¢ for each dollar's worth of food stamps (Madden and Yoder, Lane). All families of the same size receive the same dollar value of stamps, enough to purchase the components of the thrifty food plan. The difference between what a recipient pays for the stamps and their face value is termed "bonus stamps."

In January 1976, some 19.1 million persons (9% of the population of the United States and its territories) participated in the Food Stamp Program (U.S. Congress, Senate 1976b). Federal Food Stamp Program benefits were 18% of federal government expenditures on public aid in 1975 (U.S. Dep. Commerce 1976). Throughout the country, the Food Stamp Program is the only program available to the working poor and others in need of income supplementation who are not eligible for categorial welfare or other transfer programs.

The Model

The model used in estimating values of coefficients for determining Food Stamp Program outlays across counties was

$$Y_i = a + bP + cPA + dA + eT + fB + gI + hCG + iCR + jCC + kN + lLF_n + mV + nRV + oX + pU \quad (i = 1, 2),$$

where Y_1 is 1975 dollar outlays for bonus stamps divided by county population (equation (1)), Y_2 is 1975 dollars outlays divided by the county population below the low income or poverty threshold (equation (2)), a through p are constants, P is the percentage of persons in the county in poverty in 1970, PA is the number of persons in the county on public assistance, A is the percentage of persons in the county over 65 years of age and poor, T is the percentage of persons in county under 18 years of age, B is the percentage of population in the county that was Black, I is the percentage of population in the county that was Indian, CG is the characterization of the county as more or less urban or rural on a 0 to 8 scale (USDA 1975a) (a binary variable was used for each of the eight classes; fringe counties were omitted), CR is the census region, CC is whether a core county (1) or not (0), N is whether a new standard metropolitan statistical area, LF_N is the labor force participation rate (male), V is how population voted in 1968 (1 = Democratic, 0 = not Democratic), RV is the percentage of registered voters who voted in the 1968 election, X is the expenditure on another public program (in this case, CETA I),[2] and U is the unemployment rate in the county.

The model was estimated using ordinary least squares and cross-section data. We realize the "real world" may dictate use of a more complex model. Concentrations of poor persons may lead to increasing awareness of and participation in the program. Similarly, one could assume a variety of interactions and simultaneities between, for example, partici-

[2] CETA Title I funds, the largest expenditure component of the Comprehensive Employment and Training Act (1973), support manpower services provided in local areas. Such programs include outreach efforts, testing and assessment programs, orientation and counseling services, training programs, transitional public service employment, and labor market information programs. (U.S. Dep. Labor).

pation in a voluntary social welfare program and the percentage of those who voted or a simultaneity between outlays per poor person and the poverty population. However, this work is exploratory, our justification for using a model incapable of reflecting all real world conditions.

Data on 1975 dollar outlays for Food Stamp Programs bonus stamps and expenditures on the Comprehensive Employment Training Administration Title I Program were obtained from Federal Information Exchange System tapes. Data for the Food Stamp Program were originally compiled by the Food and Nutrition Service, USDA. Data used directly or for the construction of variables *a* through LF_N and variable *U* were obtained from the county characteristic profile tapes prepared by David Brown and Fred Hines of the Economic Development Division, Economic Research Service, USDA. Data on how the population voted in the 1968 election and on the percentage of voters who voted in the 1968 election were obtained from *County and City Data Book 1972* (U.S. Dep. Commerce 1973).

The dependent variable used in the equation—bonus stamp outlays per person—provides one indicator of the geographic distribution of bonus payments. Since the Food Stamp Program is oriented primarily toward poor persons, a second dependent variable, bonus outlays per poor person, was employed. Neither indicator is a perfect measure of local benefits, but both are useful in estimating the extent to which food stamp benefits are diffused across counties. The bonus stamp value per poor person focuses on only one subset of the eligibility group, the poor, and the census definition of poverty is not coterminous with the Food Stamp Program definition. The bonus stamp value per capita measure is more inclusive, accounting for the temporarily unemployed needing food.

The explanatory variables reflect the demographic composition of the county, the socioeconomic status of both the poor and nonpoor populations, and county attitudes as expressed by participation in a human resources program, political tendency, and the extent of voting. The variable *PA*, the percentage of a county's population receiving public assistance, indicates the importance of the poverty population in each county and/or the extent to which poor persons obtain public assistance. "Percentage poor" is an indicator of county need, while "percentage obtaining public assistance" reflects variance in eligibility criteria as well as the propensity or ability of those in need to receive cash support.

A second set of independent variables focuses on the demographic composition of the county's population. Economic and demographic variables have been recognized as important determinants of participation in the Food Stamp Program (USDA 1975a), although their effects on outlays per capita have not been studied. Two age variables, the percentage of a county's poor population over 65 and the percentage of a county's population under 18, are indicative of the relative importance of populations frequently in need of food stamps (U.S. Dep. Commerce 1976). Since minority populations suffer a disproportionate incidence of poverty, the percentage of a county's population that is Black or Indian provides yet another dimension of likely need for food assistance.

Labor force variables are used to indicate relative economic needs arising from a lack of income-earning opportunities. The male labor force participation rate (LFPR) is indicative of longer term economic conditions reflecting both the propensity of the male adult population to seek employment and the extent to which attractive types of work are available in the area, while the unemployment rate indicates the probability of finding employment. Unemployed persons are an important subset of those eligible to receive food stamps.

A unique set of variables was introduced to explore local attitudes toward social programs in general, local willingness to expend federal funds, and "public mindedness." The percentage of a county's population that voted in 1968 and a dummy variable to distinguish counties with Democratic congressional representation are employed as crude indicators of county attitudes. A better indication of county attitudes toward social programs is provided by a county's willingness to adopt a voluntary social program designed to assist low income persons. In this analysis, counties that elected to participate in CETA Title I programs were distinguished from those that did not. One other variable, census region (*CR*), with the Northeast omitted, was included to explore the possibility of regional differences.

One objective of this study was to assess the distributional equity of outlays across geographic areas. Since neither the value of stamps to which eligible households of equal

size and income are entitled nor purchase requirements vary across geographic regions, the only geographic differences that should arise are those associated with systematic variation in family size, net family income, or rates of participation.

Findings

The models used to explore the determinants of bonus stamp outlays per person and per poor person across county classes generally indicate: (*a*) that rurality does decrease bonus stamp outlays per capita and per poor person; (*b*) that variables that measure the extent of poverty and public assistance participation are the most important determinants of bonus stamp outlays; (*c*) that local attitudes, as expressed by partisan political choices and, more importantly, county participation in a voluntary human resources program, are significant determinants of per capita bonus stamp outlays; and (*d*) that economic and demographic variables have their expected effects on bonus food stamp outlays. The significance of both geographic and attitudinal variables suggests factors not envisaged in the authorizing legislation are, in fact, partially determining per capita food stamp outlays across counties.

The urban bias of the Food Stamp Program is evident from the coefficients (table 1). Movement from urban to rural settings along the urban-rural spectrum lowers per capita bonus outlays at an increasing rate. The urban county groupings had small and insignificant coefficients, while the rural groupings had coefficients that were significant and highest in the most rural county class. Per capita outlays were reduced by \$7.26 in the most rural county grouping. Outlays per poor person behaved in a similar fashion. Core and urban county benefits were higher and rural counties' benefits lower by up to \$50.44 per poor person. The pattern and significance of the rurality variable provides solid evidence of an urban bias in the Food Stamp Program.[3]

Compared with other regions, counties in the North Central region obtained lower food stamp benefits per capita and per poor person. Being in the South was positively associated with outlays per capita but negatively associated with outlays per poor person. Being in the West was not significant for outlays per capita, but outlays per poor person were significantly higher. Being a new SMSA was insignificant.

The most important determinants of food stamp bonus outlays were those variables indicating the size of the eligible population, i.e., poverty and unemployment measures. Per capita outlays increased by \$176 with each 1% increase in the percentage of the county's population below the poverty line and a further \$93 for a 1% increase in those on public assistance.[4] Combined with an unemployment rate coefficient of \$120 per capita, these results suggest concentrations of poor persons tend to fare better than the dispersed poor. But food stamp outlays per poor person are insensitive to the percentage of poor persons. This regression indicates those eligible must first be entered in public assistance rolls before outlays are significantly increased. Interestingly, a 1% increase in the unemployment rate increases bonus outlays per poor person by \$662, the most powerful impact on outlays.[5] Male labor force participation rates were insignificant.

The significance of public assistance and unemployment indicates poverty alone is insufficient to assure access to the Food Stamp Program benefits. Those on public assistance are automatically eligible for food stamp benefits, and the unemployed may be made aware of benefits by an employer, union, or friends. The rest of the eligible population may have to rely on local "outreach" efforts. If local attitudes hinder such efforts, participation and hence benefits may be lowered.

Variables used to assess local attitudes reinforce the hypothesis that local efforts significantly affect the distribution of food stamp benefits. Counties that participated in CETA Title I programs also "reward" poor persons with an additional \$14 in food stamp benefits. Similarly, voting and, in particular, voting Democratic tends to increase both per capita and per poor person outlays.

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[3] Rural families tend to be larger and have lower incomes, on average, than urban families. Therefore, Food Stamp Program outlays should be higher per capita or per poor person in rural areas than in urban areas.

[4] Before 1974, public assistance households comprised a relatively stable 61% of all food stamp participants. In 1975 nonpublic assistance participating households first outnumbered public assistance households, and the trend has been projected to continue (U.S. Congress, Senate 1975a, b).

[5] The ratio of the coefficient to its standard error is largest for the unemployment variable. Of course, a 1% increase in unemployment is a relatively large change, and this should be kept in mind in interpreting the coefficient.

Table 1. Regression Results for Variations in 1975 Federal Food Stamp Program Dollar Outlays, 3,097 Counties

Variable	Program Outlays per Capita (1)	Program Outlays per Person in Poverty (2)
Constant	−26.39	22.33
Percentage "poor"	176.43	−15.89
	(7.05)[a]	(34.03)
Percentage on public assistance	93.27	269.08
	(8.12)	(39.15)
Percentage poor over 65	−4.24	13.34
	(3.79)	(18.29)
Percentage under 18	50.07	145.12
	(6.53)	(31.50)
Percentage Black	−8.50	−11.27
	(2.18)	(10.49)
Percentage Indian	−85.40	−250.85
	(5.27)	(25.44)
New standard metropolitan statistical area	−0.90	−4.03
	(1.27)	(6.14)
Labor force participation rate—male	−0.22	4.32
	(2.76)	(13.34)
Voted Democratic	4.45	22.02
	(0.58)	(2.83)
Unemployment rate	120.15	662.00
	(11.64)	(56.18)
Attitude (CETA Title I)	2.34	14.40
	(0.77)	(3.72)
Percentage voted	0.11	−0.39
	(0.02)	(−0.11)
Census region 2 (North Central)	−3.05	−26.84
	(1.01)	(4.86)
Census region 3 (South)	1.70	−2.93
	(1.11)	(5.36)
Census region 4 (West)	1.18	12.00
	(1.13)	(5.47)
County group 1	0.61	24.00
	(1.27)	(6.13)
County group 3	−0.31	−10.61
	(1.25)	(6.03)
County group 4	0.59	9.00
	(1.29)	(6.24)
County group 5	−1.09	−20.69
	(1.45)	(6.97)
County group 6	−2.24	−32.18
	(1.14)	(5.48)
County group 7	−3.18	−39.58
	(1.13)	(5.42)
County group 8	−3.31	−34.64
	(1.32)	(6.38)
County group 9	−7.26	−50.44
	(1.19)	(5.77)
R^2	65.4	28.1

[a] Standard errors in parentheses.

Demographic variables had their expected impacts. Concentrations of minority populations tend to reduce outlays per person and per poor person, while the presence of more children increases outlays. The impact of the elderly poor and of the male labor force participation rate were insignificant.

Coefficients of determination were 65.4 for the per capita outlay model and 28.1 for the per poor person equation, the difference most likely attributable to variation in the percentage in poverty across counties. In part, R^2's are not higher because these models explore the determinants of per capita outlays across

counties, reflecting variance in participation as well as differences in family size and income. Although attitudes are known to affect participation, our simple indicators of attitudes presumably do not capture all local variations across county groups in such factors affecting participation (U.S. Congress, Senate 1975a, b), and some unmeasurable variables have been omitted.

Conclusions and Policy Implications

Federal efforts to assist low income persons are moving to embrace the concepts of income supplementation and universality. The Food Stamp Program is one of the major income supplement and income redistribution programs in the United States. As the only federal assistance program that permits the "working poor" to participate, it demonstrates that assistance programs can be inclusive rather than categorical. Its 19 million participants rival those of the Social Security Program, permitting food assistance and retirement assistance to be the bulwarks of the federal social welfare effort.

How well does the Food Stamp Program distribute funds to those of equal "need"? The record is mixed. Outlays per capita under the program are greater where there are higher percentages of poor people, higher percentages receiving public assistance, or unemployed people. On the basis of these indicators the program appears to be meeting income supplementation needs and may be termed an efficient program. However, where there are higher percentages of Black or Indian people, outlays per person and outlays per poor person are lower. There are regional differences, and, in more rural county groups, both per capita and per poor person outlays are lower. Higher outlays per person and per poor person accrue to core counties, the most metropolitan of all.

Despite the tendency of outlays to increase with poverty, the program does not appear to be uniformly equitable. Since federal income supplemention programs are national in scope, they generally abstract from known differences between urban and rural areas. Our findings support the hypothesis that there are structural differences between rural and urban areas that make for an implicit bias against rural areas in the distribution of program benefits. Distributional inequity may also be due to the attitudes of the county population as reflected by program administrators on the county level. Counties that participated in CETA Title I also had higher Food Stamp Program outlays per person and per poor person, a possible reflection of need as well as program administration. Outlays were higher in counties with a higher percentage of the eligible population that voted, and per capita outlays were higher in counties that voted Democratic.

What recommendation may be made on the basis of these findings? If the program is to meet existing needs as currently defined, participation rates should be increased. This would imply the encouragement of outreach efforts directed in large part at minorities. This recommendation is obviously contentious, since it would increase program expenditures. But it must be judged in the light of what the program is trying to achieve as an income supplement program, which raises the question of whether it is the best program for that purpose. However, the Food Stamp Program is politically palatable, and presently a comprehensive cash income supplement program is not.

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Using Federal Outlays Data to Measure Program Equity: Opportunities and Limitations

Fred K. Hines and J. Norman Reid

Since the late 1960s, annual reports on federal spending in small areas have been available. This effort was initiated in the Community Services Administration (CSA) (formerly the Office of Economic Opportunity) in 1966 to monitor poverty program funds and was soon expanded to include most federal activities. Currently, the CSA has working annual files and published volumes for fiscal years 1968 through 1976. Published reports known as the *Federal Outlays* series are issued separately for each state and list the amounts of individual program funds spent by federal agencies in each county and in each city with a population of 25,000 or more. In total, over 1,300 program entries are reported for each county unit in the United States. The *Federal Outlays* is the only comprehensive series of county-level data on the federal government's spending.

Earlier editions of the reports suffer from serious problems of completeness, accuracy, program identification, and definition, many of which have been resolved in recent issues. Beginning with the 1975 issue, program identification was greatly improved by labeling programs with the program numbers given in the *Catalog of Federal Domestic Assistance* (U.S. Office of Management and Budget). This matching provides the user of the Outlays files easy access to the program descriptions in the *Catalog*.

The purpose of this paper is two-fold: to provide illustrations of how the *Federal Outlays* data series can be used to address equity issues at the substate level and to give a brief overview of the current limitations of this data series. In exploring equity issues, the Outlays data are used in conjunction with data from the census of population, census of governments, Internal Revenue Service, and selected state departments of taxation. The equity analysis uses data from 1972, the latest year for which comparable data from all sources were available. The simple equity analyses that follow are illustrations of possible uses of the Outlays files and are not meant to provide firm answers to equity issues in federal spending.

Fred K. Hines is an economist and J. Norman Reid is a social science analyst with the Economic Research Service, U.S. Department of Agriculture.

An extended version of this paper is available from the authors.

Using the Federal Outlays Data in Equity Analyses

The definition of equity is not well settled among either scholars or politicians, and various conceptions may be found in both analyses and grant-in-aid formulas. Aside from definitional differences, equity analyses can be conducted on several levels. The appropriateness of individual equity criteria in part depends on the analytic level at which one focuses. Many analyses have focused on federal aid programs, principally grants, often treating groups of related programs comprising a functional area. Other studies have evaluated the distribution of funds under individual programs (U.S. President 1977, National Science Foundation, De Leon and Le Gates). Finally, there has been some interest, heightened by attention to the "sunbelt" issue, in the analysis of total federal spending (e.g., macrolevel equity) and its relationship to the strength and growth of state and regional economies (Havemann, Stanfield, and Peirce; Jusenius and Ledebur).

The following sections focus on equity questions from different levels of program aggregation and by using alternative measures of equity. First, a micro approach is taken by relating selected individual program funds to proxies for target populations from the Census of Population (U.S. Dep. Commerce 1972).

Second, for selected states, differences in per capita outlays for community development and urban renewal are compared with differences in fiscal capacity and fiscal effort at the local and state level. Finally, a macro approach is taken to assess equity in total federal spending among metropolitan and nonmetropolitan areas and regions under three equity criteria.

Microlevel Equity Analyses

Perhaps the most common method of evaluating equity is to weigh expenditures for a function against variables indicating need; for example, variables indicating the size of the poverty population might be used to weigh the distribution of poverty funds, just as measures of the quality or quantity of available housing might be used to evaluate housing funds. Such need measures are frequently used in grant allocation formulas—poverty level population, percentage unemployed, age of housing stock, and population aged 65 and over are examples.

As one illustration, the *Fourth Annual Report on Government Services to Rural America* (U.S. President 1974) compares the distribution of fiscal year (FY) 1972 outlays for social security benefits and grants to states for public assistance (welfare) payments with selected target variables. Social security old-age and survivors benefits were distributed among metropolitan and nonmetropolitan county groups in approximately the same proportions as the aged population. However, relative to the distribution of the poverty population, the distribution of public assistance grants strongly favored metropolitan counties. Nonmetropolitan counties contained 39.8% of the poverty population but received only 26% of federal outlays for welfare programs. The difference is almost entirely attributable to the Aid to Families with Dependent Children program (AFDC). While some states have elected to provide benefits to intact families, the AFDC program is geared primarily to poverty families with female heads. Since relatively fewer nonmetropolitan poverty families are headed by females (23.2% versus 39.8% for metropolitan families), a smaller share of the nonmetropolitan poor are eligible for welfare payments. In addition, only 19.6% of AFDC outlays accrued to nonmetropolitan counties, despite the fact that 27% of the population under 18 in female-headed poverty families resided in nonmetropolitan counties. Further, almost 40% of the total poverty population under 18 years of age were nonmetropolitan residents. This disparity reflects the fact that the rural states have generally set lower benefit levels than their more urbanized counterparts.

Another equity measure that commonly appears both in program analyses and grant-in-aid formulas is fiscal capacity—the ability of the area to finance its public services from its own revenue sources. This criterion assumes that areas with the lowest capacity are least able to provide adequate services from their own resources. Although there are various means of measuring local fiscal capacity and differing views as to which is the most appropriate, the most frequently used measure is average per capita personal income (Nathan, Manvel, and Calkins).

The highest per capita community development funding was directed toward metropolitan counties, with core counties in the largest standard metropolitan statistical areas (SMSA's) receiving an average of $23 per capita, nearly twice the average for the four states used in the analysis (table 1). Counties in both medium and small metropolitan areas had higher outlays than most nonmetropolitan counties, and only the fringe counties in larger SMSA's received less than the nonmetropolitan average. As measured by per capita adjusted gross income,[1] the pattern of fiscal capacity is just the reverse; average incomes in the metropolitan counties were well above the four-state average, while nonmetropolitan counties ranged from roughly 60% to 85% of that figure. Although one might conclude from these figures that community development and urban renewal grants were distributed inequitably among metropolitan and nonmetropolitan counties, the four sample states were selected because of the availability of state tax data and the same conclusion might not hold for the entire nation.

A related equity measure is tax effort, which argues that areas that tax themselves at a higher percentage of their capacity deserve larger shares of federal aid. This criterion is one element in the general revenue sharing formula. State and local government taxes as a

[1] Adjusted gross income is the result of reducing gross income from all sources subject to the federal tax by adjustments for business expenses, moving expenses, depreciation, sick pay, losses from sales of capital assets, carryover of "net operating loss" to businesses, and contributions by the self-employed to retirement funds.

Table 1. Community Development and Urban Renewal Grants Compared with Fiscal Capacity and Tax Effort Levels, Selected States, 1972

Item	Number of Counties	Per Capita Community Development and Urban Renewal Grants	Adjusted Gross Income per Capita		State-Local Taxes as Percentage of Income	
			Dollars	Percentage of Four State Average	Tax Effort Factor[b]	Percentage of Four State Average
Total, four states[a]	282	13	3,431	100.0	12.4	100.0
Metropolitan total	87	15	3,635	105.9	12.0	97.6
Greater metropolitan areas	26	19	3,793	110.6	12.5	100.8
Fringe counties	18	6	3,620	105.5	10.6	85.5
Core counties	8	23	3,848	112.2	13.1	105.6
Medium metropolitan areas	33	12	3,658	106.6	11.6	93.5
Lesser metropolitan areas	28	10	3,159	92.1	11.3	91.1
Nonmetropolitan total	195	7	2,713	79.1	14.5	116.9
Urbanized counties						
Adjacent to an SMSA	33	6	2,966	86.4	12.4	100.0
Not adjacent to an SMSA	6	2	2,837	82.7	20.1	162.1
Less urbanized counties						
Adjacent to an SMSA	64	10	2,537	73.9	15.6	125.0
Not adjacent to an SMSA	33	5	2,394	69.8	14.3	115.3
Totally rural counties						
Adjacent to an SMSA	25	4	2,109	61.5	18.9	153.2
Not adjacent to an SMSA	34	12	2,541	74.1	15.4	125.0

Sources: Outlays data: U.S. Community Services Administration; income data: U.S. Treasury Dep.; state-local tax data: U.S. Dep. Commerce, and various state sources as described below.

[a] The four states included in this analysis are Colorado, Florida, Louisiana, and Ohio.

[b] The tax effort factor is total state and local government tax collections in each county as a percentage of adjusted gross income. Total state tax collections by county were estimated. Figures were obtained from the 1972 annual report of the Colorado Dep. Revenue for income tax liability, motor vehicle registration, and net sales tax by county; these taxes, which equaled 60.4% of total state taxes in 1972, were inflated to equal total state tax collections. Florida tax collections by county were obtained from the Florida Comptroller's 1972 *County Finances and Fee Officers Report*, which reported data for major state taxes comprising 73.8% of the total; the county totals for these taxes were inflated to equal the state total. Michael and Jones estimated total 1969 Louisiana state tax burdens by parish, which were inflated to equal 1972 total state tax levels. Data for fiscal 1972 sales, personal income, motor fuel, and cigarette tax collections in Ohio counties were provided by the Ohio Dep. Taxation. Total tax collections in each county were estimated by inflating these taxes, which comprised 60.4% of the total, to 100%.

percentage of adjusted gross income are compared with per capita outlays for community development and urban renewal programs in table 1. In general, this criterion suggests an inequitable distribution of community development and urban renewal grants, though the pattern is not entirely consistent. Tax effort is higher in nonmetropolitan counties than in metropolitan counties, while per capita outlays for community development were higher in SMSA's than outside them. However, within metropolitan counties, the highest outlays go to the core counties, which have the highest tax effort, while the lowest tax effort, in the fringe counties of larger SMSA's, is rewarded with the smallest level of federal community development spending.

Macrolevel Equity Analyses

The recent "sunbelt-frostbelt" debates have focused attention on yet another level of equity analysis—the effect of total federal spending on state and regional economies. In this section, three measures of equity in total spending are illustrated: total outlays relative to income level, total outlays relative to federal personal income tax liability, and federal effort (federal tax liability as a percentage of income) relative to outlays.

Comparisons of the levels of per capita outlays in nonmetropolitan and metropolitan areas and census regions with their average per capita incomes are made in table 2. The figures suggest that nonmetropolitan areas gain less than equitable shares of outlays—both per capita incomes and outlays are lower in nonmetropolitan counties—and that the West gains more than equitable portions of outlays.

A second way of evaluating whether spending is equitably distributed is to compare spill-ins of spending with spill-outs of federal taxes. The analysis here compares per capita outlays

Table 2. Equity Measures for Studying Federal Outlays among Metropolitan and Nonmetropolitan Counties by Regions, 1972

Item	Federal Outlays	Federal Personal Income Tax Liability	Per Capita Adjusted Gross Income		Ratio of Federal Outlays to Tax Liability		Federal Personal Income Tax Liability as a Percentage of Adjusted Gross Income	
			Dollars	Percentage of U.S.	Total	Percentage of U.S.	Total	Percentage of U.S.
	--$/Capita--							
U.S. total	1,062	459	3,565	100.0	2.31	100.0	12.9	100.0
Metropolitan total	1,125	512	3,873	108.6	2.20	95.2	13.2	102.3
Greater metropolitan areas	1,219	565	4,172	117.0	2.16	93.5	13.5	104.7
Fringe counties	889	631	4,537	127.3	1.41	61.0	13.9	107.8
Core counties	1,368	535	4,009	112.5	2.56	110.8	13.3	103.1
Medium metropolitan areas	998	459	3,578	100.4	2.17	93.9	12.8	99.2
Lesser metropolitan areas	1,016	402	3,241	90.9	2.53	109.5	12.4	96.1
Nonmetropolitan total	896	318	2,751	77.2	2.82	122.1	11.6	89.9
Urbanized counties								
Adjacent to an SMSA	915	372	3,116	87.4	2.46	106.5	11.9	92.2
Not adjacent to an SMSA	1,067	342	2,914	81.7	3.12	135.1	11.7	90.7
Less urbanized counties								
Adjacent to an SMSA	751	306	2,678	75.1	2.45	106.1	11.4	88.4
Not adjacent to an SMSA	876	293	2,577	72.3	2.99	129.4	11.4	88.4
Totally rural counties								
Adjacent to an SMSA	854	252	2,309	64.8	3.39	146.8	10.9	84.5
Not adjacent to an SMSA	1,065	251	2,295	64.4	4.24	183.8	10.9	84.5
Northeast	1,131	540	4,044	113.4	2.09	90.5	13.4	103.9
Metropolitan	1,181	566	4,179	117.2	2.09	90.5	13.5	104.7
Nonmetropolitan	829	381	3,209	90.0	2.18	94.4	11.9	92.2
North Central	844	470	3,619	101.5	1.80	77.9	13.0	100.8
Metropolitan	834	530	3,939	110.5	1.57	68.0	13.5	104.7
Nonmetropolitan	865	341	2,926	82.1	2.54	110.0	11.7	90.7
South	1,090	392	3,097	86.9	2.78	120.3	12.7	98.4
Metropolitan	1,243	463	3,499	98.1	2.68	116.0	13.2	102.3
Nonmetropolitan	841	277	2,439	68.4	3.04	131.6	11.4	88.4
West	1,262	451	3,672	103.0	2.80	121.2	12.3	95.3
Metropolitan	1,272	479	3,857	108.2	2.66	115.2	12.4	96.1
Nonmetropolitan	1,221	340	2,946	82.6	3.59	154.4	11.5	89.1

Sources: Outlays data: U.S. Community Services Administration; income tax liability and adjusted gross income: U.S. Treasury Dep.

with personal income tax liability.[2] By this measure, nonmetropolitan areas as a whole receive a net benefit at the expense of metropolitan counties with the least populous nonmetropolitan counties receiving the highest net inflow of federal dollars. The primary losers are the fringe counties in the nation's largest SMSA's, which both pay high taxes and receive back comparatively little federal expenditure. Similarly, the southern and western regions are significant net beneficiaries, both in their metropolitan and nonmetropolitan areas.

A third way of looking at equity in the distribution of total outlays is to consider them in relation to the federal tax burdens borne by the residents of each area. Here, we measure federal tax burden as federal personal income tax liability as a percentage of adjusted gross income. While there is some relationship between the average federal tax effort and outlays to metropolitan and nonmetropolitan counties, that relationship is hardly a consistent one (table 2). The metropolitan counties as a whole bear higher than average tax burdens and receive in return higher than average outlays per capita. Within the metropolitan

[2] Although federal income taxes comprised only 45% of all federal revenues in fiscal year 1972, they are used here to compare with outlays because data on other sources of revenue, such as corporate income taxes and employment taxes, are unavailable at the county level.

and nonmetropolitan groups, however, there is little apparent relationship. The figures for the four regions support this conclusion; the two regions with the highest average tax effort rank second and fourth, respectively, in per capita outlays.

Limitations of the Federal Outlays Data Series

The major limitations of the current Outlays files relate to the methods used to estimate and report county level outlays, matching individual programs with their descriptions in the *Catalog of Federal Domestic Assistance,* and year-to-year changes in the Outlays data and in federal programs themselves, which result in problems in using the data in time-series analyses.

Allocation Methods

For fiscal year 1976, only 27.6% of all outlays reported to the county level represented actual outlays rather than estimated amounts.[3] Over two-thirds (71.6%) of the funds were allocated to the county level by a variety of proration techniques. These allocation methods were used because of the difficulty of accounting for federal spending at such levels of geographic detail and of coordinating the reporting effort across all federal agencies.

The proration methods differ widely in sophistication and, as a result, in their probable effects on research conclusions. A majority of the programs, with nearly half of total outlays, involve proration methods that are reliable enough that the data can be used with some confidence. Of these programs, those involving the largest amounts of money are primarily benefit payments to individuals whose county level expenditures are estimated on the basis of target population size (the number of recipients) by assuming an equal benefit payment per case.

There are a number of programs, involving nearly a quarter of total outlays, for which the county level detail is not reliable enough to support valid research conclusions. Of these, the most important group includes both grant and contractual spending programs for which the county level spending is either unknown or unmeasurable and for which no attempt at proration was made. Included in this group are federal payments to prime contractors and formula grants to state governments, for which the Outlays data report only the initial payment and not the final expenditure of the money by the intermediaries. In addition, spending under some thirteen programs is estimated on the basis of each county's population, clearly too crude a method to support valid research conclusions.

Matching the Outlays Series with the Catalog

One of the major improvements in the *Federal Outlays* data in recent years resulted from identifying many Outlays program categories with program numbers appearing in the *Catalog of Federal Domestic Assistance.* The descriptive detail in the *Catalog* helps to flesh out the cryptic program titles in the Outlays publications and is of great benefit to the researcher, who might otherwise have to struggle to identify the content of programs.

Despite its value, the *Catalog,* which contains descriptions of the main characteristics of over 1,000 federal aid programs, including most grants-in-aid and a number of other forms of assistance, was intended to help state and local governments and other applicants to identify their potential eligibility for federal assistance. Thus, it is often inadequate as a comprehensive and reliable classification of the programs and activities reported in the *Federal Outlays* files. While the *Catalog* does not include all federal programs, it does purport to contain most discretionary federal assistance programs such as grants, loans, and technical assistance. As a result, the *Catalog's* lack of comprehensiveness may have less serious effects on equity analyses taking a micro approach (viewing equity for individual or selected groups of programs) than on those taking a more macrolevel view (as measured by total federal outlays).

The *Catalog's* value is further limited by occasional changes in its program classifications from one issue to the next, by alterations in the identification numbers that apply to a particular program, and by a lack of full coordination between the *Catalog* and the Outlays. The need for better coordination be-

[3] Federal outlays include all spending by the federal government's executive branch agencies, including such items as grants-in-aid to state and local governments, salaries and administrative expenses, military procurement and research contracts, and transfer payments to individuals (such as social security and civil service retirement benefits). The outlays amounts are not budget outlays as displayed in the annual budget documents but primarily represent funding obligations and new loan commitments. The method used to report outlays varies: some programs report on a cash basis, while others report on an obligations basis (e.g., the amounts of new awards of funds) or some other basis.

tween the two series is illustrated by comparing the *Catalog* identification numbers used in the 1976 Outlays publication with the most recent year they were listed in the *Catalog*. Of the 645 *Catalog* numbers referenced in the 1976 Outlays files, 92.5% (597) were described in the 1976 *Catalog*. However, the Outlays files used 24 catalog numbers that were not described in the current *Catalog* (though they were listed in earlier issues); an additional 24 program numbers have never been listed in any issue of the *Catalog*. While such discrepancies between the two sources remain irritating to the researcher, the *Catalog* remains the most useful available tool for identifying individual programs found in the Outlays files.

Using Outlays Data in Time-Series Analyses

One benefit of an annual data series is its potential for use in time-series analyses. The researcher who attempts to use the *Federal Outlays* data in this fashion faces several obstacles, of which the most significant is the difficulty of identifying equivalent component programs in each of several years. The constant change in federal policy, as new programs are created and old ones consolidated or eliminated outright, is a major source of frustration in such time-series efforts. The difficulties are magnified when the study involves a period of major transition in federal policy from one set of programs to another. An improved *Catalog of Federal Domestic Assistance* could support time-series analyses by helping researchers to identify and trace changes in federal policies and programs over time.

Summary and Conclusions

The illustrations in this paper point out the potential value of the Outlays series and the usefulness of the data when used in conjunction with other statistical series. The analysis demonstrates the measurement of equity at several different levels and uses various criteria for equity. The results indicate clearly that the choices of both level of analysis and evaluative standards are important ones that can be expected to have a significant impact on research findings.

The paper also considers the limitations of the *Federal Outlays* data series. The major advantage of the Outlays data is its high level of detail, both geographically and programmatically, which makes it amenable to the pursuit of hypotheses that could not otherwise be addressed. Its primary limitation centers around the fact that much of the county-level detail are estimates, rather than actual figures. Approximately 27% of the programs, involving 72% of total outlays on the 1976 file, employed some allocation technique to arrive at county-level figures. However, about two-thirds of these outlays used allocation methods that were judged to be acceptable for most research purposes. Many of the allocation techniques could be improved or eliminated entirely by incorporating other existing statistical series into the Outlays data reporting activity.

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Assessing Public Policies and Programs: Equity Considerations: Discussion

Glenn L. Nelson

Harper and Tweeten present results that should stimulate interesting and useful hypotheses. They manipulate a rich source of data with a logical sequence of statistical routines. The limitations of factor analysis (Armstrong) and the problems of pretest bias in a succession of regressions (Debertin) warrant additional emphasis. But the authors are more careful in recognizing the value of prior information than many of their colleagues and are also aware their hypotheses need confirmation before application.

The failure of Harper and Tweeten to recognize explicitly the larger dynamic and macroeconomic setting is an important shortcoming. A major issue in the current debate of income redistribution is the trade-off between equality and efficiency (e.g., Campbell). Efficiency in the context of this debate includes encouraging the innovation and investment that maximizes future production as well as insuring incentives exist for appropriate allocations in the current period. The underlying premise is that redistribution of income discourages both the contributor and recipient from putting their resources into the most productive uses. This very hypothesis was a prime motivation for the experiment whose results are being analyzed by Harper and Tweeten. Once this trade-off is recognized and accepted, knowledge of the marginal utility of income among groups at a point in time, while useful, is clearly an inadequate base for policy formation.

Harper and Tweeten are overly anxious to have this type of study influence policy formation. A one-dimensional measure of the quality of life, a few explanatory variables possessing the usual problems of measurement and correspondence to theoretical constructs, and a regression equation are inadequate for the complex problems that confront us. The analysts who make an important contribution to equity issues in public policy in the near term will be those who explain "who gains, who loses, and why" along several socioeconomic dimensions and leave the weighting of the dimensions and the fixing of marginal utilities to the political process. The research reported by Harper and Tweeten is valuable but not as an immediate input to policy.

The paper by Hines and Reid contains a good, concise description of the *Federal Outlays* data and other closely related series. The illustrations of comparisons of outlays with other demographic and economic variables are useful demonstrations of descriptive studies. Such studies address the issue of "who gains and who loses" from a variety of perspectives, which, as noted earlier, is information much sought after and needed in political discussions. This account by two experienced analysts is a useful reference for those who wish to pursue studies with these data.

The major problem with the Hines and Reid paper is their failure to go beyond description in either illustrations or general discussion. The impacts on equity that they address are limited to initial impacts defined in narrow terms of who directly receives funds from or forfeits funds to the public treasury. The missing element is an analytic framework that would facilitate identification and measurement of causal factors and indirect impacts. Indirect impacts on regions, industries, occupations, and other variables may either reinforce or counter the initial impacts of programs (e.g., see Golladay and Haveman).

The description of the allocation procedures raises the question of whether analysts would be better advised in many cases to limit their analysis to rates of participation, i.e., recipients of outlays relative to members of the target population. When federal outlays are allocated to counties based upon their propor-

Glenn L. Nelson is an associate professor in the Department of Agricultural and Applied Economics, University of Minnesota, St. Paul.

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tion of program participants, a comparison of estimated outlays and estimated target population is fundamentally one of comparing participant and target populations. A direct analysis of the participation rate would be more straightforward and less likely to be misinterpreted.

The paper by Martin and Lane possesses problems of conceptualization and interpretation. Part of the problem is the lack of a clear statement at the outset of how equity is to be measured. The authors cite numerous studies showing socioeconomic variables, such as location and race, that affect food stamp utilization. Martin and Lane apparently regard an equitable situation as one in which families of equal size and equal net income receive equal bonus stamps regardless of other socioeconomic factors. If this interpretation is accepted, the relevant objective is to quantify the impact of socioeconomic factors associated with different levels of bonus stamps among the eligible people. Such a study is valuable.

People of middle and higher socioeconomic status receive no, or extremely few, bonus stamps. This is easily explained by the income limitations of the program and is consistent with equity as defined above. An econometric analysis is not required. The equation explaining food stamp outlays per capita serves little or no useful purpose.

In conclusion, the definition of the concept of equity being investigated should be clearly stated in policy analysis. Distinctions between nominal and real goals are especially important in rural-urban comparisons. Should people receive more public assistance if they choose to live in high cost areas? How does this relate to our goals of the appropriate spatial distribution of people and economic activity? Which equity goals, if any, are best accomplished at regional, state, and local levels rather than nationally?

Research on equity issues should be conducted with an awareness of an integrated conceptual framework that includes indirect impacts and other macro considerations. Economic theory is at least as relevant in equity as efficient issues.

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Resident Instruction
(Milton M. Snodgrass, New Mexico State University, Chairperson)

Personalizing Learning Processes in Agricultural Economics

Dayton Young Roberts and Hong Yong Lee

The past two decades have witnessed a resurging emphasis on the study of self as a concern of American education, a concern that had almost disappeared in the wake of the behavioristic tide generated by Watson and his followers in the 1920s. Today, numerous theorists and practitioners contend that self-concept theory and self-concept activities are vital ingredients in the educative process. Maslow, Rogers, Combs, and Purkey, among others, have related well the dynamics of self to motivation and behavior. Combs (1962, 1965) suggested that teacher preparation be based on a perceptual, self-concept approach, and at the University of Florida in 1969 he spearheaded an experimental program emphasizing the development of sensitivity, empathy, and capacity for effective interaction in teacher trainees.

The scarcity of such efforts, however, led Purkey to observe that "little has been done to equip teachers . . . with simple clinical techniques and instruments which would enable them to be more sensitive to their students" (pp. 57–58). What little has been done consists almost exclusively of preservice preparatory programs for teachers at the elementary and secondary levels.

A distinct departure, perhaps the first of its kind in preservice and in-service preparatory programs for teachers at the junior and senior college level, was the "Humanistic Approach to Learning" model and program, introduced and implemented at the University of Florida in 1971 and continuing from Texas Tech University under the title "Personalizing the Learning Climate."

Since 1971, more than 2,100 preservice and in-service college teachers and administrators have participated in the seminars and workshops of the program. The participants have been introduced to current self-concept theories, have experienced clinical tecnhniques, and have responded to instruments designed to increase their sensitivity and awareness of themselves, putting them in a better position to help build positive and realistic self-concepts in their students.

The instruments administered to these participants are, for the most part, forced-rank-order instruments dealing with attitudes toward personal values and with key questions related to their roles as college teachers. An analysis of the rank-order a teacher assigns the various structured responses offered in a list of terms or statements provides insight into specific attitudes and values of the teacher; the instruments are similarly revealing when directed at and administered to students. The following rank-order question is administered first since it serves to demonstrate the validity of personality type study to the participants, and this is essential for the success of the program: As an instructor, what do you think students look for when they enter a class for the first time? Rank the following from 1 to 7: friends in the class, number of assignments, instructor's personality, specific learning objectives, instructor's grading system, course reading requirements, and types of tests given.

As reported by Park in his 1971 ERIC study and by Roberts (1973, 1974) in two more recent studies, college faculty and college students at all levels most frequently rank "instructor's personality" number one. This revelation accompanied by a renewed interest in the psychological theories of Jung led to the use of the Myers-Briggs Personality Type Indicator as the principal and most sophisticated

Dayton Young Roberts is a professor of higher education and Hong Yong Lee is an associate professor of agricultural economics, Texas Tech University.

self-concept instrument used in the personalized learning program.

The Myers-Briggs Type Indicator (MBTI) is a self-administered 166 item self-validating instrument published in 1962 by the Educational Testing Service (Myers 1962). The MBTI and the supporting research stemming from its development expanded and clarified Jung's theory that seemingly chance variation in human behavior is in fact not due to chance; it is the logical result of observable and measurable differences in mental functioning.

These basic differences concern the way people use their perceiving processes to become aware of people, things, occurrences, or ideas and the way they use their judging processes to come to conclusions about what has been perceived. Since the two together—perception and judgment—are central to a person's mental activity, they determine, to a great extent, that person's overt behavior.

Jung's theory states further that there are two ways of perceiving—by sensing and by intuition—and two ways of judging—by thinking and by feeling. In addition to whichever of these processes an individual prefers, there will be an accompanying preference for introversion or extraversion. Thus, the MBTI defines the following pairs of preferences from which sixteen different combinations of personality type may be derived:

(*a*) Extraversion (E)/introversion (I): the direction of interest. Does the subject's interest flow mainly to the outer world of actions, objects, and persons (E) or to the inner world of concepts and ideas (I)?

(*b*) Sensing (S)/intuition (N): how situations are perceived and experienced. Does the subject attach more importance to the immediate realities of direct experience (S) or to the inferred meanings, relationships, and possibilities of experience (N)?

(*c*) Thinking (T)/feeling (F): judgment preferences. In making judgments, does the subject rely more on logical order and cause and effect (T) or on priorities based on personal importance and values (F)?

(*d*) Judging (J)/perception (P): lifestyle. Does the subject prefer to live in the judging attitude, systematically planning, ordering, and organizing his world, deciding what needs to be done and attempting to control events (J) or in the perceptive attitude, spontaneously, curiously, awaiting events and adapting to them (P)?

The preferences in type processes result in sixteen combinations of personality types (table 1).

In spring 1977 two members of Texas Tech University agricultural economics faculty participated in the second annual series of faculty development workshops titled "Personalizing the Learning Climate at Texas Tech." Their involvement in this program led to the typing of agricultural economics faculty and students with the MBTI.

Seventy-seven upper division students majoring in agricultural economics at Texas Tech University were typed with MBTI. In addition, eleven agricultural economics faculty members were also typed with the MBTI. Typology distribution of students and teachers, as shown in table 2, reveal (*a*) a much higher percentage (78%) of students are sensing (S) versus intuitive (N) than teachers (55%), (*b*) an overwhelming majority (82%) of teachers are judging (J) versus perceptive (P), whereas less than one-half of the students are judging (42%), and (*c*) a much higher proportion (82%) of teachers are thinking (T) versus feeling (F) than students (64%).

In spite of a rather small sample of teachers used in the study, disparities of the personality-type distributions found between faculty and students of agricultural economics at Texas Tech University is quite typical in higher education throughout the nation. The disparities point to the fact that a preponderance of sensing (S) types are being taught by teachers who are more apt to be intuitive (N) type than students. Sensing types do not see, hear, and/or experience things in the same manner as intuitive types. The higher the sensing score or the intuitive score, the more pronounced become these differences in perceiving things. Because of these differences, sensing types do not prefer the same teaching and learning staples as intuitive types. While intuitive types like to read, sensing types tend to favor other methods for learning.

Further analyses of the typology distribution indicate (*a*) nearly one-third of students are sensing-feeling (SF) type compared with none for teachers, (*b*) close to one-half of the students (45%) and teachers (55%) are sensing-thinking (ST) type, (*c*) only 4% of students, compared with 18% of teachers, are intuitive-feeling (NF) type, and (*d*) 18% of students and 27% of teachers are intuitive-thinking (NT) type. In her *Introduction to Type* Myers (1976) states that sensing-thinking types focus their attention on facts and handle

Table 1. MBTI-Type Distribution

	Sensing		Intuitive		
	Thinking	Feeling	Feeling	Thinking	
Judging	ISTJ	ISFJ	INFJ	INTJ	Introversion
Perceptive	ISTP	ISFP	INFP	INTP	Introversion
Perceptive	ESTP	ESFP	ENFP	ENTP	Extraversion
Judging	ESTJ	ESFJ	ENFJ	ENTJ	Extraversion

these with impersonal analysis. Thus, they tend to be practical and matter of fact and find scope for their abilities in such occupations as production, construction, accounting, business, economics, law, etc. Sensing-feeling types tend to be sociable and friendly. They are more likely to find occupations in sales, service, customer relations, welfare work, general practice, etc. Intuitive-feeling types find scope for their abilities in research, teaching, counseling, preaching, writing, psychology, etc., while intuitive-thinking types are more apt to be happy in such fields as research, science, invention, securities analysis, management, pathology, etc.

Students majoring in agricultural economics at Texas Tech University are predominantly (78%) possessors of personalities that tend to favor occupations in production, accounting, business, economics, sales, law, service, customer relations, etc. In view of the fact that employment opportunities for graduates with degrees in agricultural economics are most abundant in those fields mentioned above, it should be considered as a very healthy situation.

Interestingly, of the three students whose MBTI showed ENTJ type, two of the students are planning to pursue advanced studies in agricultural economics with full intention to become researchers.

Analysis of academic performances of the 77 students based on their work completed at Texas Tech University revealed that only two categories of MBTI-types showed statistically significant deviations in the distributions of students within each MBTI-type (table 3). Of the 77 students, 18 students (23.4%) had a grade point average (GPA) of less than 2.0 on a 4.0 point (for A) scale, 35 students (45.4%) had a GPA between 2.0 and 2.74, and 19 students (24.7%) had a GPA between 2.75 and

Table 2. Typology Distribution of 77 Agricultural Economics Students and 11 Faculty, Texas Tech University, Spring 1977

	Students	Faculty	Students	Faculty	Students	Faculty	Students	Faculty
	ISTJ		ISFJ		INFJ		INTJ	
No.	7.0 (9.1%)	3.0 (27.3%)	9.0 (11.7%)	0 (0%)	0 (0%)	1.0 (9.1%)	0 (0%)	1.0 (9.1%)
	ISTP		ISFP		INFP		INTP	
No.	7.0 (9.1%)	0 (0%)	7.0 (9.1%)	0 (0%)	2.0 (2.6%)	1.0 (9.1%)	6.0 (7.8%)	0 (0%)
	ESTP		ESFP		ENFP		ENTP	
No.	11.0 (14.3%)	0 (0%)	5.0 (6.5%)	0 (0%)	1.0 (1.3%)	0 (0%)	5.0 (6.5%)	1.0 (9.1%)
	ESTJ		ESFJ		ENFJ		ENTJ	
No.	10.0 (13.0%)	3.0 (27.3%)	4.0 (5.2%)	0 (0%)	0 (0%)	0 (0%)	3.0 (3.9%)	1.0 (9.1%)
	ST		SF		NF		NT	
No.	35.0 (45.5%)	6.0 (54.5%)	25.0 (32.5%)	0 (0%)	3.0 (3.9%)	2.0 (18.2%)	14.0 (18.2%)	3.0 (27.3%)
	Sensing (S = ST + SF)				Intuitive (N = NF + NT)			
No.	60.0 (78.0%)	6.0 (54.5%)			17.0 (22.0%)	5.0 (45.5%)		

Table 3. Distribution of 77 Agricultural Economics Students by MBTJ-Type and Grade Point Average

Grade Point Average[a]	Frequency							
	Observed	Expected[b]	Observed	Expected	Observed	Expected	Observed	Expected
	ISTJ		ISFJ		INFJ		INTJ	
<2.00	0	1.6	0	2.1	0	0	0	0
2.00–2.74	4	3.2	5	4.1	0	0	0	0
2.75–3.49	3	1.7	2	2.2	0	0	0	0
>3.49	0	0.5	2	0.6	0	0	0	0
χ^2	4.11[c]		5.58		0		0	
	ISTP		ISFP		INFP		INTP	
<2.00	1	1.6	4	1.6	1	0.5	2	1.4
2.00–2.74	3	3.2	2	3.2	1	0.9	3	2.7
2.75–3.49	3	1.7	1	1.7	0	0.5	0	1.5
>3.49	0	0.5	0	0.5	0	0.1	1	0.4
χ^2	1.73		4.84		1.11		2.69	
	ESTP		ESFP		ENFP		ENTP	
<2.00	6	2.6	1	1.2	0	0.2	0	1.2
2.00–2.74	1	5.0	4	2.3	1	0.5	4	2.3
2.75–3.49	4	2.7	0	1.2	0	0.2	1	1.2
>3.49	0	0.7	0	0.3	0	0.1	0	0.3
χ^2	8.46		2.79		1.00		2.79	
	ESTJ		ESFJ		ENFJ		ENTJ	
<2.00	2	2.3	1	0.9	0	0	0	0.7
2.00–2.74	4	4.5	3	1.8	0	0	0	1.4
2.75–3.49	2	2.5	0	1.0	0	0	3	0.7
>3.49	2	0.7	0	0.3	0	0	0	0.2
χ^2	2.61		2.11		0		9.86	
Total								
<2.00	18	18						
2.00–2.74	35	35						
2.75–3.49	19	19						
>3.49	5	5						

[a] Based on grade point average on work completed at Texas Tech University on a 4.0 point for A scale.
[b] Same distribution for each MBTI-type is assumed as the distribution for the total.
[c] Statistically significant χ^2 values are 7.81 and 11.3 at 5% and 1% levels, respectively, for 3 degrees of freedom.

3.49, while 5 students (6.5%) had a GPA of more than 3.5. Of the 11 ESTP-type students, 6 students had a GPA of lower than 2.0 (compared with an expected number of 2.6), 1 had a GPA between 2.0 and 2.74 (compared with an expected number of 5), and 4 students had a GPA between 2.75 and 3.49 (compared with 2.7 expected). All three ENTJ-type students had a GPA between 2.75 and 3.49, which resulted in a significant χ^2 value. Even though two categories of MBTI-types showed a statistically significant χ^2 test, the MBTI-type is hardly an indicator of students' academic performances based on the sample of 77 students.

It appears that the greatest value of information of MBTI of students lies in aiding teachers in their counseling activities and in their teaching. As an example, it might be a mistake for a teacher to urge a sensing-feeling type student to pursue a career in research. Assuming that the sample of 77 students at Texas Tech University is a fair representation of agricultural economics students throughout the nation, it would be advisable for teachers to use teaching techniques that rely less on intuition and reading and more on sensing and factual materials. The study also points out the necessity of teachers to be extremely patient whenever they are involved with teaching materials that require much abstraction and/or conceptualization. Teachers in agricultural economics should neither expect the majority of their students to grasp readily anything that requires much intuition nor lose patience

when students fail to conceptualize in abstract.

In the first issue of *Findings*, the Educational Testing Service quarterly devoted to research in postsecondary education, Warren states, "New means of accommodating student diversity are clearly needed, and one approach is to assess the personal preferences or learning styles of the students and adapt instructional procedures accordingly" (p. 4).

Teaching and learning styles and their relation to Jungian personality preferences are now being investigated in numerous studies around the country, particularly at Texas Tech University. Findings indicate clearly that sensing and judging types prefer to teach and learn in an orderly, systematic manner using primarily their five senses and that they respond positively to varied multimedia instructional approaches and do not respond as well to the written or the spoken word (e.g., textbooks and lectures) when used alone as instructional media. The intuitive and perceptive types, on the other hand, prefer to teach and learn in a flexible, unstructured manner. They are more apt to respond positively to the written and spoken word, providing that these stimulate interest and imagery. Responses to such stimuli may range from hunches to creative discoveries. It appears then that students exhibiting these contrasting personality preferences to any significant degree should not be taught or treated in the same manner nor should they be given the same types of assignments.

In his preface to Brawer's *Personality Characteristics of College and University Faculty*, Arthur Cohen wrote, "One must know who and what one is if he is to be successful in teaching, a most humane profession" (p. III). American higher education has not accepted completely the premise that teaching is a most humane profession, especially at the college level, but when it does, exploration of self-concept and personality theories and the matching of teaching and learning styles with personality preferences will play key roles in the humanizing process.

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Increasing Conflicts over Land Use: Conceptual Issues and Practical Problems (Daniel W. Bromley, University of Wisconsin, Chairperson)

The Economics of Agricultural Land Preservation

B. Delworth Gardner

Several state legislatures are considering enactment of tight zoning laws to preserve high productivity land for agricultural use. In the vernacular of the day, this land is referred to as "prime" (Raup, pp. 2, 3). Apparently, the myriad of tax preferential policies and other planning devices designed to protect agricultural lands from conversion to other uses have not been very effective (Hansen and Schwartz). Some of our best agricultural land continues to be converted to expanding urbanization, transport, utility easements, and for a variety of public purposes. So it is argued by those who advocate zoning for agricultural land that more drastic measures are now needed to stop this avalanche before "serious" agricultural land shortages occur.

Of course, if social action is needed to retain prime land in agricultural use, the land market cannot efficiently allocate land resources among competing uses. The tax preference schemes were enacted to make it less costly to use land for agricultural purposes so that significant quantities of land would be kept in agricultural use that would otherwise shift. But use changes could still occur through the market if value differentials were great enough to offset the production cost advantage created by the tax preference. The crux of the proposed prime land preservation legislation is quite different; it removes the land allocation decisions from the market entirely by using productivity criteria to qualify land for preservation and by granting the power for exemptions and use changes to designated boards.

This paper is largely concerned with the economic implications of this drastic policy shift. There must be substantial political pressure for retaining prime agricultural land since proposals are numerous and are being made in all sections of the country. It is the thesis of this paper, however, that the economic costs and benefits of such proposals have not been adequately explored and that it is the obligation of agricultural economists to do so. Not even the philosophical rationale for removal of the market from land use decisions has been adequately considered (Ervin et al.). This paper is more of an exploration of this issue than it is an empirical demonstration of market efficiency.

The next section discusses the perceived benefits of prime land preservation; the third section discusses market failure and the alleged justification for social intervention; the fourth section treats the selection criteria that have been proposed to qualify prime land and how the program will be administered; and the final section highlights the major efficiency and equity implications of market removal from land allocation.

Before proceeding, it is significant that it is not only the states that are agitating for preservation of prime agricultural land. The U.S. Department of Agriculture (USDA) has clearly gone on record in supporting the notion also. There is no compelling evidence as to the need for preserving prime agricultural land found in the background papers presented at the Seminar on Retention of Prime Lands (Krause and Hair).[1] Despite this fact, those writing the summary volume, *Recommendations on Prime Lands,* said the following:

Discussants for this session were Paul W. Barkley of Washington State University, James C. Hite of Clemson University, and Phillip M. Raup of the University of Minnesota.

B. Delworth Gardner is the director of the Giannini Foundation of Agricultural Economics and a professor of agricultural economics, University of California, Davis.

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[1] Evidence presented at the seminar points to the opposite conclusion: there is likely to be ample agricultural land and forestland to meet food and fiber requirements until the turn of the century and after.

"USDA should take a major, defined, and well-promoted role in the national questions of utilization, enhancement, and retention of agricultural lands as an advocate of retaining the maximum possible base for the production of food, fiber, and timber products, and minimizing actions that will diminish the nation's capacity to produce these essential commodities" (USDA 1975, p. 17). This may be effective rhetoric in attempting to convince agricultural producers that the USDA is looking after their interests, but, taken literally, the statement cannot be taken seriously. Will anyone in the USDA really advocate retaining the maximum possible land base in agriculture? This would be essentially all land since at some cost nearly all land could be used for agricultural purposes. Or can anyone believe that actions that diminish the nation's capacity to produce food and fiber should be minimized, i.e., reduced to zero? To answer "yes" would require stopping all developments that compete with agriculture for resources and all environmental and safety regulations that impinge on agriculture.

On 21 June 1976, acting secretary of agriculture in the Ford Administration, John A. Knebel, issued Secretary's Memorandum No. 1827, Supplement I, "Statement on Prime Farmland, Range, and Forestland," which contained the following recommendations for USDA agencies in regard to prime land: (*a*) advocate the protection of prime lands from premature or unnecessary conversion to other land uses; (*b*) assure that environmental impact statement procedures and review processes thoroughly consider and evaluate the impact of major federal actions on prime farmland, range, and forestlands; (*c*) emphasize programs to inventory, assess, and evaluate the nation's farmland, range, and forestlands; (*d*) initiate cooperative efforts with states, local governments, and universities to assure that concerns for food, fiber, and wood production are recognized and emphasized in the identification of prime lands; (*e*) USDA agency actions and programs should give consideration to local, state, and national concerns for the retention of prime lands; and (*f*) programs of the agencies in the Department should be reviewed to insure consistency with the intent of this supplement.

President Carter's team in the USDA has espoused the cause with equal if not greater enthusiasm. Rupert M. Cutler, assistant secretary of agriculture for conservation, research, and education, said on 9 June of this year, "How far can we as a nation go in continuing to permit the kidnapping of prime farmland for housing and industrial use without gravely endangering our capacity to meet the food needs of our people and our food commitments to the disadvantaged people of the world? How far can we go before we upset irrevocably the environmental balance—if we have not already done so?" (Cutler, p. 3). Cutler goes on to indicate that he has reestablished the USDA Land Use Committee that "will be busy looking at an appropriate mix of tools for preserving prime farmland and other values, such as land use controls, land acquisition, easements, tax and other financial incentives." (p. 6).

The above makes it quite clear that this powerful federal agency is supporting fully the idea of retaining prime agricultural land by extramarket means. Since such legislative actions as have been proposed to date might involve "high" societal costs, a significant loss of freedom of landowners, and may even be inimical to the interests of most farm operators, this strong USDA advocacy is premature and may be regretted.

The Benefits from Prime Land Retention

Some of the issues incorporated in agricultural land retention are expressed in Assembly Bill No. 15 introduced in California during the 1975–76 legislative session:[2]

> The legislalure finds and declares that the preservation of agricultural land is of paramount interest to the welfare of the State of California in that the preservation of such land, especially prime agricultural land, is critically important in order to assure and to maximize the food, fiber, open space, and employment opportunities which are necessary for present and future generations of the state and the nation.

What society appears to get in the action of preserving agricultural land are at least four joint products (benefits)—three of which are referred to in the above quote: (*a*) "sufficient" food and fiber to meet the nutritional requirements of a growing national and world population; (*b*) local economic benefits that derive from a viable agricultural industry; (*c*) open space and other environmental amenities that

[2] This bill was passed by the Assembly but defeated by the Senate in 1975–76. Other very similar bills have been introduced in the 1976–77 and 1977–78 sessions. At the moment of this writing, all are help up in the Senate Committee on Agriculture and quite possibly will be tabled there.

accrue chiefly to urban residents; and (*d*) more efficient, orderly, and fiscally sound urban development.

Given that these are the joint benefits that will hopefully be achieved by retaining high productivity land in agriculture, what is the rationale for extramarket social action? To put the question another way, why won't the land market allocate socially optimum quantities to agricultural use? To move toward an answer, it is useful to relate the various joint benefits that derive from agricultural land use to the theory of market allocation of resources.

Market Failure and Prime Land Retention

So long as product and factor markets are perfectly competitive, goods are private as contrasted with collective, and no externalities exist, it is generally conceded by economists that the free market will allocate the socially optimal quantity of land to various competing uses. Thus, if the market is removed from the allocation task and is replaced by essentially nonmarket allocation criteria as is proposed by the prime land preservation legislation, some rationale should be offered. In addition, the consequences in terms of economic efficiency and equity should be carefully evaluated.

If some of the joint benefits from land discussed above are collective goods, it is granted that the free market will not allocate land among uses efficiently. Collective goods have two fundamental characteristics: the impossibility of excluding consumers who do not pay for the good in question and consumption by one consumer occurs without reducing the quantity of the good available for other consumers (Mishan 1969). Thus, if a good is a collective good, the marginal supply cost of extending its consumption is zero; therefore, the efficient supply price would be zero. At a zero price, obviously no private entrepreneur would be willing to invest in its supply, and no supply would be forthcoming. The market simply cannot handle the supply problem.

External effects may be defined as unpriced or improperly priced effects emanating from production or consumption activities that impinge on the welfare functions of third parties (Mishan 1976).[3] Establishing that externalities exist may not automatically mean a departure from Pareto optimality. It depends on the costs of negotiating mutually satisfactory arrangements to establish liability for the externality (Coase). In any case, the existence of unnegotiated and uncompensated external effects may be another example of market failure in land allocation among uses and a justification for social action.

Collective goods and externalities are the two most often cited examples of market failure but not the only ones. Two others are monopoly or monopsony in product or factor markets and so-called merit goods. There appear to be no advocates of prime land retention who have justified agricultural zoning on the basis that land markets have been monopolized or monopsonized, although speculation is an issue that is often raised. In the case of merit goods, there are some "food fundamentalists" that have argued that food is such a basic human need that the private land market should not be allowed to determine the acreage devoted to food production. Food and fiber should be provided to all as a "right" and should not be governed by market criteria.

Another member of the family of market failure is the distortions in prices caused by public policies of various kinds. There are a large number of these running the gamut from environmental and safety regulations to agricultural income and price policies. Two especially significant and vexing practices that affect land allocation and ownership are the taxation of real property by local government and provisions in the Internal Revenue Code that make agricultural land an attractive way of holding wealth.[4] The first practice discriminates against real property and may create cash flow problems for owners that wish to utilize land in low valued uses. It does not discriminate against agricultural use of land per se, however. The second practice may discriminate in favor of agricultural use of land if the Internal Revenue Service (IRS) regulations provide tax loopholes that make it especially profitable to own agricultural land. Clearly, IRS regulations have had a significant impact on who owns agricultural land if not on the aggregate acreage in agricultural use.

Let us now turn to the four joint products alleged to be significant in prime land retention and see if there are elements of market failure

[3] This definition rules out so-called "pecuniary" effects as qualifying as external effects since they are by definition price effects.

[4] William W. Wood, Jr., and L. T. Wallace called attention to these important factors in reviewing an earlier draft of this paper.

that justify the removal of the land market from allocation decisions.

Except for the merit good argument suggested above, it is difficult to see why the market will not allocate sufficient land to food and fiber production. The food and fiber sector of the economy is as competitive as any other, and food and fiber prices adjust rapidly to changing conditions in supply and demand. The enormous increases in agricultural land prices of the last five years have been due principally to expectations for higher food and fiber prices at the farm gate. If further increases are expected, there is nothing inherent in the land market that would prevent these expectations from yielding even higher land prices. The more productive the land, the higher the agricultural land price can be expected to be and the more competitive agriculture will be for land vis-à-vis other land uses. The greater the comparative advantage of American agriculture and the fewer the impediments to free world trade in agricultural commodities, the greater will be the demand facing our producers, the higher the profitability of producing food, and the stronger the competitive position of agricultural producers who compete for prime land.

The collective good and externality arguments do not seem very relevant when applied to food and fiber. These products meet all of the requirements of private goods, and significant external effects are not obvious in consumption. There may be external diseconomies in production of good and fiber (such as the use of chemicals), but this would suggest too much effort in production—not too little. Of course, if land and these chemicals were good substitutes rather than complements, more land and less chemicals may well be more efficient.

The merit-good argument is more difficult to deal with on rational grounds. If one believes that food and fiber are somehow special (like safety and education apparently are), this may suggest setting prices below marginal supply costs. Even such a cheap food policy ought to require that a given amount of food and fiber be produced at minimum factor opportunity cost to society. Some system will be required to establish land values within agricultural uses and between agricultural and other uses. It is not easy to see how this can be better accomplished by removing land allocation from the market and using noneconomic criteria instead.

Decision makers across the spectrum of agriculture—such as farm operators, processors, farm suppliers, transporters, financial firms, university professors in agricultural fields, and government agency personnel—have obvious stakes in a viable and stable industry. Landowners are directly affected in a unique way by the prime land retention issue. If land is immobilized in agricultural use, they forfeit the direct wealth gains in price appreciation that would have occurred with the possibility of changing use in a free market. This equity problem is discussed further below. The others listed above are affected more indirectly. The wealth impacts could be substantial for them also—positive or negative. Conceptually, these indirect impacts are identical to secondary benefits and costs in traditional benefit-cost analysis. In addition, these effects are primarily pecuniary as contrasted with technological. As such, they qualify neither as collective goods nor relevant externalities in justifying interference with the land market.

Some might argue that income and wealth differences among regions may justify prime land retention in order to prop up the dominant local industry—agriculture. The argument is thin as related to these secondary beneficiaries because they tend not to be low income people. It may apply to some immobile farmworkers who may benefit if local land is left in agriculture. Many of these same issues are applicable to producing a more efficient, orderly, and fiscally sound urban development by agricultural zoning. If prime agricultural land cannot be developed for urban purposes, demand shifts to parcels that are not so zoned, conferring wealth gains on the owners of these parcels. Whether the result is a more or less efficient urban development is far from clear, however. It depends on where these parcels are, how efficient they are in producing urban amenities, what the costs are of bringing public utilities and transport to these parcels, etc. It is not obvious in principle that urban "leapfrogging" will be reduced over what the free market would have produced. Much would depend on the criteria utilized to zone agricultural land, the number of zoning variances granted, and the availability of soil types and other land classification data. Much depends also on jurisdictional boundaries and the ability of local governments to tax the parcels affected and charge the average costs of supplying public services. In any case, most of

these impacts are also pecuniary and offer only a weak justification at best for interference with the land market.

Finally, there is the case where market failure is most apparent—the creation of open space and environmental amenities. These benefits obviously meet the criteria for collective goods, and there are elements of Pareto-relevant externalities as well. Since there are no market signals, there is little evidence available as to how much these amenities are worth; but it seems clear that their value would be much higher in Los Angeles County in California than in central Wyoming. In any case, in principle at least, the market will not provide the optimal quantity of these amenities; and there may be some justification for social action to remedy this market failure.

Before exploring the implications of the conclusions reached above for economic efficiency and equity, it will be useful to be more specific about how land allocation will be done under the proposed land retention legislation.

Land Allocation under Prime Land Retention Legislation

Two major issues that must be resolved in any retention program are the criteria utilized to qualify land parcels and the administrative apparatus that will apply the criteria, make exceptions, and arbitrate disputes. Although the laws proposed in various states are no doubt somewhat different in detail, the central thrusts are very similar. The proposed California legislation will serve as an example. Much of this material is taken directly from Assembly Bill No. 15 introduced in California Legislature, 1975–76 regular session (reintroduced in the 1977–78 session as Assembly Bill No. 222).

"Prime agricultural land" means an area of land whether a single parcel or contiguous parcels that is over 20 acres in size, on the date of enactment has not been developed for use other than agricultural use, and meets any of the following qualifications: land that qualifies for rating as class I or class II in the Soil Conservation Service (SCS) land use capability classification;[5] qualifies for rating 80 through 100 on the Storie Index rating; supports livestock grazing and has an annual carrying capacity equivalent of at least one animal unit per acre; is planted with fruit or nut-bearing trees, vines, bushes, or crops that have a nonbearing period of less than five years and produces an annual unprocessed gross crop value of not less than $200 per acre; and has returned an average annual gross income of $200 per year in unprocessed plant products.

The criteria set out above seem to rule out the forced retention of small parcels (under 20 acres) and land already put to a nonagricultural use at the time of enactment. Thus, the central issue focuses on the scope of qualification criteria and how much land currently in agricultural use may escape inclusion.

It is significant that the wording of the bill specifies that land that meets any of the above criteria qualifies. So long as gross crop income exceeds $200 per acre, land will qualify regardless of capability class and Storie Index rating. Some rough yield and price calculations reveal that there is not much commercial agricultural land in California that does not produce gross crop income of at least $200 per acre. At average yields and prices in 1976, of the hundreds of crops grown in the state, only oats and barley failed to yield $200 per acre. They are most often doublecropped with other cash crops like tomatoes and sugar beets. Thus, it is quite clear that not much land under cultivation in California will escape prime classification because of this feature of the law.

Nearly all land use bills introduced in California apply both the SCS classification system and the Storie Index to designate which land is prime agricultural land. Several of the bills require the land to rate I or II in the SCS system and between 80% and 100% on the Storie Index. Another bill (SB 1710) includes also land classed as III in SCS and drops the Storie Index from 60% to 100%. The two classification systems use approximately the same factors but combine and weight them differently. The result of using the two systems is that, occasionally, land classed as "prime" under the one may not be so under the other.

How do the two compare? The Storie Index is older and has been traditionally used in California but not in the rest of the country. The SCS system has been expanding in usage even in California. The SCS system has twelve categories of classification: effective soil depth, surface layer texture, permeability, drainage,

[5] Two bills introduced in California during the current legislative session vary slightly from Assembly Bill 15 in the land qualification criteria and in the administrative framework under which the law will be administered.

available water capacity, slope, erosion hazard, flooding hazard, salinity, alkali, toxic substances, and length of frost-free season (USDA 1973). In each category soil is rated I (best) through VIII (worst). The lowest rating in any one category pulls the entire classification of the land down to that level.

The Storie Index is based on four factors that parallel some of the SCS categories (Storie). The percentage ranks achieved in each factor are multiplied together. If less than 100% is attained in each, the Index declines multiplicatively (for example, 60% × 85% × 95% × 90% = 44%). Factor A is similar to the first classification under SCS. The rating is based on the profile of the soil, how hard the clay pack is, and how deep the topsoil cover. Factor B rates the surface texture. The rating is among three extremes—all clay, all sand, or all silt. The best combination of the three called loam would rate 100% in factor B. The rating declines as any of the three extremes is approached. Factor C rates the slope of the land from nearly level (0 to 2% slope) as 100% rating to very steep (45% slope and over) as from 5% to 30% rating. Factor X combines several of the SCS categories: drainage, alkali, nutrient level (fertility), acidity, erosion hazard, and microrelief (smooth through dunes). The percentages attained in any of the subcategories of factor X are multiplied together to give the percentage for factor X.

It is significant that both the land capability classification systems and the Storie Index are strictly oriented toward physical productivity. Location plays no role whatever. Because of the point made earlier that agricultural productivity may not be the only purpose for land retention in agriculture or even the major one, criteria that do not include location factors may be quite inefficient in producing desired results. After all, enhancing environmental amenities, removing competition for urban land parcels, and preventing urban sprawl are all tied up in the location of the land parcels affected. Urban people who want these joint products of land retention may well be frustrated and disappointed in the results of a land preservation scheme that retains land in agricultural use based only on agricultural productivity criteria.

With respect to the administrative issue, the proposed California legislation creates an agricultural resources council that would have the primary function "to delineate and map the location and boundaries of prime agricultural lands . . . to prescribe various land uses which may be permitted within areas designated as prime agricultural land; and upon certification, such land could only be used as so prescribed." The council would clearly "call the shots" in land use decisions.

The council would have twelve members as follows: (*a*) three representing counties (incumbent county supervisors), (*b*) three representing cities (incumbent city councilpersons), (*c*) three representing the public, and (*d*) the secretary of agriculture and services agency, the secretary of the resources agency, and the director of finance. Lest anyone conclude that the council would be dominated by local interests, vis-à-vis state interests, it need only be pointed out that the individuals in (*a*), (*b*), and (*c*) are to be appointed by the Governor, the Senate Rules Committee, and the Speaker of the Assembly (each gets to name one person in each group). Obviously, if one political party or one philosophy of government dominates the political scene in Sacramento, the decisions of the agricultural council would likely be dominated by the same party or philosophy.

The legislation provides that the council shall adopt regulations prescribing the various land uses that may be permitted within areas designated as prime agricultural land. Such regulations shall automatically apply to any activity of a local agency or to any authorization, lease, permit, license, or entitlement for use issued by a local agency of government. Cities, counties, special service districts, etc., may petition the council for exemptions, plan modifications, or remapping, but the legislation makes it clear that the council is the final arbiter.[6]

Efficiency and Equity Implications of Market Allocation versus Prime Land Retention

Efficiency Implications

As pointed out previously, the effect of the prime land retention proposals is to remove land allocation decisions from the market and

[6] Assembly Bills 437 and 1900 and Senate Bill 193, introduced in 1977, give much more responsibility to local government. Each city or county must adopt an agricultural plan that would contain four components: an agricultural land preservation plan, a plan to resolve conflicts between competing land uses, mapping all prime agricultural lands, and an agricultural inventory component. Even though many rural politicians favor these bills over Assembly Bill 15, it is unclear which, if any, will ultimately be adopted.

give them to local or state planning councils. There are many reasons for believing, a priori, that the efficiency costs of taking this step will not be inconsequential.

Consider a hypothetical example (Gardner and Zivnuska). Suppose that land parcel A yields an annual surplus (revenue minus non-land costs) of $100 per acre in the developed use and $50 in agricultural production (table 1). An alternative parcel B has an annual surplus of $150 in developed use and $90 in agriculture. If the relevant capitalization rate is 10%, parcel A would be worth $500 per acre to agricultural owners and $1,000 to developers. Developers must pay at least $500 to get $1,000 and would capture a potential maximum wealth gain of $500 per acre. In the case of parcel B, they are willing to pay the agricultural value of $900 in order to get a capitalized value of $1,500, a difference of $600 per acre. The competitive land market will allocate B for development if there is sufficient demand for only one of the competing parcels. This market solution is socially optimal, assuming no Pareto-relevant external effects, as society captures a larger rent in foregoing agricultural production on parcel B ($60 per annum) than it would have in the case of parcel A ($50 per annum).

Perhaps the above conclusion results from the numbers chosen rather than from any economic principle. To see that this is not so, consider a third parcel C that has comparable agricultural value with parcel B (annual surplus in agriculture of $90) but is only slightly better for developed purposes (say, $101 annual surplus) than the poorer agricultural land parcel A. Let us now compare parcels A and C as this comparison prompts the question usually asked by prime land advocates; namely, why allow good agricultural land to go to developed uses when poor agricultural land will do nearly as well? Will the market now take the better agricultural land (parcel C) when the poorer land (parcel A) would do nearly as well in the developed use? Clearly not! Developers would have to pay $900 to get parcel C, which would be worth $1,010 to them, and they stand to get a gain of $110. If they can get A, they would gain $500 as has been already demonstrated. As before, in the absence of externalities, the perfectly competitive market produces a socially efficient allocation of land.

Table 1. Hypothetical Surplus Values Yielded in Developed and Agricultural Uses

Use	Parcel A	Parcel B	Parcel C
Developed	100	150	101
Agricultural	50	90	90

The same can hardly be said for a land-planning council guided by agricultural productivity criteria as described above. Comparing parcels A and C, they would direct that A should be developed, which would be the efficient choice. But in choosing between A and B, they would select parcel B to remain in agriculture every time unless they succumb to the pressures (if not bribes) of the developers (Lewis and Kuttler). If they do, the prime land retention scheme is innocuous in its allocation effects anyway. But society would have to carry the burden of an administrative agency that is in the business of passing out windfall gains and/or wipe-out losses, most often with adverse equity consequences.

Because the point has been made so often, it seems almost trite to add that there is no good substitute for the market in providing signals in the form of prices that reflect relative scarcity of resources and relative values of these resources in alternative uses. A set of firm property rights is the institution that permits the market to serve this function efficiently. When property rights are altered, such as would be the case if land disposition is restricted, the signals are distorted, and the market does not work efficiently. If society really has a scarcity of agricultural land and food and fiber prices are not artificially controlled at lower than equilibrium levels, the land market serves perfectly well to reveal this scarcity. If this effective instrument for revealing scarcity is replaced by the prime land retention schemes proposed where inadequate economic or political criteria dictate resource allocation, there is no reliable way of knowing whether agricultural land is becoming scarcer or more plentiful.

None of this argues that there are not now encroachments on the free exercise of property rights. There are, as the discussion above on taxation points out. What is argued here is that existing encroachments do not clearly reduce the acreage in agricultural use below the social optimum and that, therefore, no new encroachment is needed to offset existing ones.

Another common allegation is that in investment decisions the market is shortsighted

compared with political processes. In fact, do the actors operating in the market have a bias toward the present that is socially inefficient? The land "speculator" is that bad guy who makes his living predicting the future more accurately than the rest of us. He has an incentive to do his job well, and market prices reflect his anticipations of future scarcity. What reasons can be advanced for believing that a part-time agricultural board member or even a career planner can do a better job of predicting the future?

This point has been succinctly stated by Gramm and Ekelund:

> A basic understanding of market decisions reveals that current land prices, and thus land use patterns, reflect both current valuations and expected future preferences. However, in a world of uncertainty, forecasts about the future are continuously being proven incorrect; and any viable system of allocating land to various uses must be capable of quickly and efficiently adjusting to these ever-changing forecasts. Those who are less adept at predicting future events will find themselves buying at high prices and selling at lower ones and eventually being forced into another occupation. Thus, the free market system provides both a payoff for accurate forecasting and a penalty for inaccurate forecasting.
>
> Planners have no direct signals to revise their initial plan until shortages have produced political pressures to alter the plan. Planners will be forced to handle pressure from private landowners who recognize the change in circumstances and seek permission to convert their lands to this use. It would be extremely naive to argue that land use planners will be able to maintain independence when no other government regulatory agency has succeeded in doing so (Gramm and Ekelund, pp. 133, 134).

Because the market is an institution where preferences can be freely expressed, although these preferences are constrained by limits on purchasing power, there is always some uncertainty associated with market allocation (Johnson). There may be less uncertainty with government allocation. By the same token, there will almost surely be more freedom of choice in the market and better information of foregone alternatives.

It is true that the market will not provide the optimal quantity of the collective good—open space. But neither will the prime land retention schemes. They preserve land on the basis of agricultural productivity and there may or may not be a good match between high productivity agricultural lands and open space for urban recreators. Given that open space is partially a joint product with agricultural use, it is an empirical question whether the land market or zoning based on agricultural productivity criteria will provide more socially optimal quantities of open space. If there is a critical shortage of open space, a sensible and efficient solution would seem to call for open space selection criteria and either zoning on that basis or public acquisition of the requisite lands in the market.

Equity Implications

Granted that there are public interests to be served in the supplying of open spaces and feeding the world's people by prime land retention, the equity issue boils down to creating these benefits by imposing a wealth loss on the owners of prime agricultural land by immobilizing the land in that use and thus preventing land use shifts at higher prices. Thus, unless compensation is given, these landowners absorb losses in order to provide the collective goods enjoyed by society as a whole.

Whether or not compensation is paid is the principal difference between the two most commonly utilized devices for social control of land resources—zoning and eminent domain. Zoning employs the police power of the state to regulate use without compensation, whereas eminent domain appropriates private property for social uses and "fair" compensation is paid. Both administrative practice and judicial decision have standardized the distinction (Pach). If the action requires an enlargement of the public's assets, as with highway building or park construction, it is normal for property rights to be acquired through eminent domain. On the other hand, if private use can be legitimately regulated in promoting public health, safety, and welfare, and there is little or no effect upon property rights, zoning through the exercise of the police power is the accepted technique.

At least one observer questions whether "open space zoning" can qualify for use of the police power of the state without the payment of compensation since "open space regulations are usually designed to protect scenic beauty, wildlife, and watersheds, rather than traditional objectives of protecting public health and preventing nuisances. When land values are severely depressed and the objectives tend toward the aesthetic, courts have leaned away from police power" (Pach, p. 25). If the arguments presented here are valid,

that agricultural zoning will severely reduce land values and that open space preservation is the primary justification for prime land retention by zoning, the conclusion stated in the quote above would seem to apply to agricultural zoning as well as to open space zoning.

Two much-discussed but little-utilized techniques designed to deal with the equity problem are zoning by eminent domain (ZED) and transfer of development rights (TDR). ZED combines eminent domain and zoning and permits the state to acquire by eminent domain the development rights for all purposes other than those permitted under the zoning plan. TDR is a system that permits property owners with restricted land to sell development rights to those whose property is zoned for nonrestricted uses. These techniques have been described and evaluated by Ervin et al. Their conclusion is that ZED is very costly to the state and is difficult to administer. They are less negative about TDR, although they do question its political feasibility. Those benefited by the system—the landowners—are likely to be far fewer in number than those who pay the compensation in the form of higher prices—the ultimate owners of new homes, offices, businesses, etc. The latter group would likely swamp the former group in an election or referendum.

Even though there do seem to be devices that can mitigate the equity problem, there has been no attempt to incorporate them in the proposed legislation, and there is even a conspicuous absence of any discussion of them. What is perhaps even more significant, there is not even any explicit recognition that an equity problem exists at all.

Summary

Perhaps the most apt way to sum up is that agricultural land retention legislation is the wrong thing at the wrong time and for the wrong reasons. The number of people clamoring for enactment and the power of the governmental agencies supporting the idea do not alter this basic conclusion.

It has not been adequately demonstrated that more American land than the market will make available will be needed to produce food and fiber in the decades ahead. Granted that the market will not provide optimal quantities of open space and that more can be justified, what sense does it make to use agricultural productivity criteria to select the land parcels desired? Additionally, even if urban growth needs to be better managed and agriculture needs to be more profitable to shore up rural economies and communities, why should immobilizing land in agricultural use be an efficient way of reaching these goals? Even if all these ends were achievable by employing the means of preserving agricultural land, what is more inequitable than requiring agricultural landowners to bear the costs in the form of foregone increases in land prices?

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Land—The Far Horizon

Sterling Brubaker

The theme of this session is "Increasing Conflicts over Land Use." Perhaps that title is a bit myopic. There have always been intense conflicts over land use—Romans versus barbarians, Indians versus settlers, fences versus range, sheep versus cattle, to name a few. Indeed, conflict over land use is more basic and is found in nature in the form of "territory" and "niche."

While man overwhelms the territorial claims of other species, within human societies conflict also arises over territorial rights. In the United States our institutions are strong enough to regulate simple territorial claims without great conflict; thus, the law determines rights where like users seek to displace one another. But conflict also comes from a different source—from the pressures of increased use and from incompatible types of use. Greater intensity of use, whether with fixed or changing technology, implies more active competition for land, and some competing uses may be excluded for economic or technical reasons. The effects of land use change are rarely confined to the plot concerned, so nonowners have a stake in the outcome. That is what is happening in our society. Whether this means that the conflict has grown more acute in our time is problematical, but at least its changing character makes us think so, and our legal and economic institutions ensure that the conflict will be extended, litigious, and inconclusive.

Now, as before, the problem is how to accommodate changing demands on the land. If new demands have sufficient economic or political force behind them, they will prevail at the expense of less insistent uses. Yet often the result is conditioned as much by shortsightedness or intellectual rigidity as it is by irreconcilable interests. We should examine ways in which the finite land could be made to serve more of our diverse wants. This helps distinguish areas of necessary conflict from those that are unnecessary. We can say something about the strength of the forces for change and where they appear to be taking us. At the same time, we need not worship the apparent result; we also should stand back somewhat and look at requirements for the preservation of our land resource and whether the emerging pattern of use is consistent with those requirements. A land economics not informed by a land ethic carries the potential for disaster.

Sterling Brubaker is a senior fellow, Resources for the Future, Washington, D.C.

The Land Use Pattern and Its Changes

The pattern of land use needs only the briefest review. As of the last complete survey of land use in the United States, forests were the largest category (32%), followed by pasture and range (27%), and then by cropland (21%). A miscellaneous category of wastelands comprised 12% of the total, and special use areas such as urban land, roads, military installations, parks, and wild life areas made up the remaining 8%. Alaska, with about 16% of the total U.S. land area, had three-fourths of the miscellaneous category. For the coterminous states, cropland amounted to 25% of the total, pasture and range 32%, and miscellaneous lands 4%, while the share of forests and special use lands was essentially unchanged (USDA 1973).

This pattern has remained remarkably stable over a period of decades. The amount of forest has changed hardly at all since 1900. As one would expect, urban lands and parks have encroached a bit on other categories, but the intensive uses in urban areas and transportation facilities remain a tiny 2.7% of the nation's land (USDA 1973). Cropland increased mainly at the expense of grassland up to the 1930s but thereafter receded slightly until the early 1970s (USDA 1973). If we use the narrower measure of cropland harvested, the decline was considerably sharper and the recovery likewise. Since the upsurge in foreign demand for U.S. agricultural production in recent years, cropland harvested again has swelled at the expense of grass, and harvested

acreage has regained the level of a quarter century ago.

While aggregate land use shifts have not been very dramatic, the figures conceal the considerable amount of churning that has gone on. The principal oscillation is between cropland and grassland and pasture. There also has been considerable shifting between cropland and forests. Geographically, this reflects the reversion to forest of much land in the Northeast and in Appalachia, while other forest lands in the Delta and elsewhere were converted to crops. Meanwhile, other new lands have been brought under cultivation, especially in Montana, Washington, California, Kansas, Colorado, Texas, and Florida. The net result is that some of the older areas ill suited to modern large-scale farming have been abandoned in favor of better terrain or climate (USDA 1974). Another major national trend is the unidirectional shift of land to urban or infrastructural uses or its designation as parkland. There also has been a steady increase in irrigated acreage (USDA 1974).

Forces Determining Land Use

What forces have shaped our land use pattern, and what is their strength for the future? Will new ones assume importance not heretofore observed? Physical capability and economic demand have been the major influences at work, though preferences expressed through public policies may play a significant role in the future.

In its extensive uses, our land use pattern reflects the physical capabilities of the land to a major degree. (Mineralized lands are an exception in all categories.) Tundra is not readily converted to anything else. High elevations likewise have limited adaptability. Arid lands may be made productive with water, but the availability of water is too limited to change most of them. Steep slopes remain productive only in trees or permanent grass. Many grasslands lack moisture to support trees or crops. Most forest land is unsuited to crops and most range unsuited for forest or crops. But in areas of moderate relief where irrigation is possible, or in more amply watered terrain of the same sort, two or more of these extensive uses may be physically possible, for example, crops, pasture, or forest. At that point the configuration of demand and costs determines uses—demand not only for food, fiber, and wood but for the amenity products and site uses of the land as well. Costs include the investment costs of converting land to other uses. So, while physical capability is very important, potential competition for land between uses is significant and must be resolved by economics or by policy.

At this point, a hierarchy of economic demands on the land asserts itself. Land sought for use as urban sites or for transportation facilities rarely can withstand that claim; such uses ordinarily outbid all others in the market or may assert eminent domain. If land is suitable for crops, this use ordinarily takes precedence over all other nonurban uses. Range and forests are residual claimants, the balance between them determined by local conditions. Obviously, this array reflects long-standing price relationships. For example, not all potential cropland has been cultivated because, with existing technology and costs, demand was not strong enough to justify it. Likewise, one could imagine a price for wood that might make forest use competitive with crops or pasture where it is not at present. Finally, while economic demand is a powerful determinant of land use, it must be remembered that public policy intervenes in a thousand ways, direct and indirect, to influence the outcome; farm price policy, trade policy, environmental regulations, tax policies, and the exercise of eminent domain are examples.

The Demand for Cropland

The physical capabilities of the land are relatively permanent. After a long period of trial and error, most present land use is consistent with physical capabilities. Of course, there will be changes in the intensity of present use. Beyond this, economic and policy factors will dominate future marginal shifts in land use within its physical capability, so that higher uses will claim suitable land as needed from lower uses. Cropland is the preeminent user of rural land. Will there be enough of suitable quality? Will crops encroach seriously on other uses? Does cropland need extramarket defense against other uses, particularly more intensive ones? To get at these questions we must consider the prospective demand for U.S. agricultural products and the technologies, as constrained by economic and environmental developments, that will be used to produce them.

Overall demand for domestic agricultural output will increase only slowly if USDA baseline projections are realized (Crosson, table 1). This scenario reflects normal population and income growth. A high demand scenario occasioned by rapidly expanding foreign demand for U.S. agricultural output represents a significantly different possibility. The implications of these two demand possibilities for land requirements depend entirely on yields. The rate of yield increase gradually declined during the 1950s and 1960s. If this yield trend is maintained, Crosson figures that baseline demand can be met with little increase in harvested land. On the same yield assumptions, the high demand projections would require about 50 million additional acres.

However, in very recent years, yields of grain and soybeans have failed to improve in line with trend. Many speculate that this is a real shift caused by exhausting the potential of known yield-increasing technologies. Others blame adverse weather, input price rises, and conversion to crops of less productive land. Whatever the reason, if yields remain relatively flat, meeting even the baseline demand will require about 50 million additional acres. Thus, on the most favorable assumptions about yields, 1985 baseline demand could be met by 343 million harvested acres, while on the least favorable yield assumptions 447 million acres would be needed for the high demand scenario (Crosson, table 4).

Farmland Availability

It would not be all that easy to find an additional 50 to 100 million acres of harvestable cropland. The idle acres of yesteryear already are back in production. While it was once fashionable to refer to 264 million acres of uncropped land in classes I to III as an ample agricultural reserve, it is now recognized that most of that land is not truly available to modern farming. A more modest appraisal was made recently by the Soil Conservation Service, which found 78 million acres with a high potential for crops as of 1974, or 111 million acres if lands of medium potential are included (USDA 1976b, table 4). However, two things need to be said about those figures: being based on 1974 cost and price relationships they give an exceptionally favorable reading on the economic viability of land conversion, and the farm economy cannot harvest every cropland acre in a given year; much of the potential added cropland would go to the categories of fallow, failure, and cropland pasture.

Presumably a high demand scenario that calls for extension of cropped area would also imply the improved cost-price relationships necessary to bring potential cropland into production. While that would be a relief to farmers squeezed by deterioration of their cost-price relationships since 1974, it could mean substantially higher food prices for the American public and might therefore become politically chancy. Would our open export policy be able to survive the resulting pressure? Since expanded exports entailing more land would bring increased environmental pressure on U.S. lands, we might find consumer and environmental interests combining to restrict exports.

At present about 335 million acres are harvested annually in the United States. The Soil Conservation Service study of potential cropland identified 400 million cropland acres. Since some land (about 30 to 40 million acres) must be held fallow, crop failure will claim another 5 to 15 million acres per year, and some cropland must be used as pasture to support the farm operation or will be unavoidably idle, clearly at 335 million or so harvested acres existing cropland is fully utilized. Net conversions from other uses will be required if harvested acreage is to increase.

Where will it come from? Of the 78 million acres considered to have high potential for conversion, over 62 million acres are in pasture and range and 13 million acres in forest (USDA 1976b, table 4). Yet some of those pasture and range acres with high potential for crops already are integrated into farm operation and not readily spared from existing use. Moreover, while most of the high potential lands are in capability classes I to III (65 million acres), only about 39 million acres rate as prime land. Prime farmland meets specific physical criteria with respect to soil quality, moisture supply, temperature regime, erodability, water problems, and the like that make it best suited to crop production. Very little additional prime farmland seems to be available. Of 384 million acres classified as prime farmland, 250 million acres presently are cropland. That leaves 134 million acres of uncropped prime land, but 86 million acres of this are rated as having little or no potential for conversion under 1974 conditions; only 39 mil-

lion acres are accorded high potential and 9 million acres medium potential. When high and medium potential lands are classified according to the kind of problems that must be overcome if they are to be converted to crops, only 42 million acres are adjudged free of problems. The other 69 million acres have one or more problems; they require clearing, face high erosion hazards or costs, lack dependable water, are subject to flooding, or have other deficiencies (USDA 1976b, table 3). In brief, the environmental costs of converting much of that land will be high in terms of erosion, floodplain encroachment, loss of wetlands, or loss of other habitat.

We have a long record of conversion of other land to crops. Over the recent past it is estimated that about 1.3 million acres per year were converted, partially offsetting the loss of farmland to other uses (Cotner). As was noted, this entailed regional shifts and the substitution of land better suited to modern farming for land that no longer met requirements. In view of the above numbers, it is difficult to see where much good quality land could come from. High demand accompanied by slow growth in yields could produce a real pinch on farmland availability a decade hence. A reach for 50 to 100 million acres could compel use of a substantial amount of lesser quality land.

Forestlands and Their Potential

A word should be said about the availability of forest land for conversion to crops. Some 43 million forested acres have been designated as prime farmland, but only 10 million acres of this is judged to have high or medium potential for conversion to crops (USDA 1976b, table 6). Some additional forestland in the Delta and Southeast may be converted to cropland, but elsewhere reversion to forest will continue in agriculturally retrograde areas. There is no likelihood that forests will take productive cropland.

Some foresters worry about agriculture encroaching on forest lands, but that seems a needless worry. Not only is the amount of forest land suited to crops limited but it is increasingly likely that potential demand for wood products can be met from less land. It is widely believed that the forest industries are on the verge of a technical revolution much like that undergone by agriculture in post-World War II years. If that is true, it means that our expanding demand for wood and pulp can be met from constant or declining acreage. Much of our forest land is poorly managed at present. Sharply higher prices would induce management improvements on the best forest land. Under intensive management, it is estimated that only one-third of the forest acreage would be required to meet wood requirements to the end of the century (Clawson).

Urban Competition for Cropland

But that is not the whole story. Urban and other uses continue to encroach on cropland. We see all sorts of numbers on the amount of rural land lost annually to urban and other special uses. The *Potential Cropland Survey* (USDA 1976b) showed 16 million acres lost to urban use and 7 million acres to reservoirs over the eight-year period 1967–75, or an annual loss of 3 million acres of which 750,000 acres was cropland. Total special use areas comprising urban, transportation, recreation and wildlife, public facilities, and farmsteads increased 27 million acres during 1959–69, most of it in the recreational and wildlife categories (USDA 1973). In addition, it is alleged that up to 2 million acres of rural land becomes entangled in the development process each year and lost to other uses (Dideriksen and Sampson). Looking only at cropland, Cotner, Skold, and Krause find cropland abandonment for all reasons of 2.7 million acres per year partially offset by new cropland development of 1.3 million acres for a net annual loss of 1.4 million acres. Of those lands converted directly to urban use, somewhere between one-fourth and one-half are cropland. In standard metropolitan statistical areas where lands are especially vulnerable to development, 18% of the land is class I and II cropland and 15% other cropland on a national basis. Overall, the picture is one of a steady loss of cropland, not at a dramatic pace, but one that forces any needed expansion of crop acreage to move against the current.

However, one can question whether urban demands on the land will continue at the previous rate. As of 1969, only 61 million acres were devoted to the two most intensive uses—35 million acres in direct urban use and 26 million acres used for transportation facilities (USDA 1973). Between 1950 and 1969, direct urban land use doubled, growing by 17 million acres to the 35 million figure, while

transportation uses increased only 3 million acres. That represents a combined annual diversion of 1 million acres. I have no data on the quality of land presently in urban use, but given the history of settlement in valleys and in agricultural areas and the easy adaptability of farmland to development, probably half of it is land suited to crops. However, it does not seem likely that we will continue to convert rural to urban land at recent rates. Our population already is urbanized and the rate of total growth has slowed. A population stabilizing at 250 to 300 million and using urban land at past ratios would require no more than an additional 9 to 18 million acres plus modest amounts for transportation facilities. If half of this is cropland, some 2% or 3% of the present cropland total might be claimed for urban use. Recent growth in urban land use clearly has been disproportionately high, reflecting the drive of Americans to spread out in suburbia.

Some believe that this trend is reversing for a variety of reasons. Demographic trends are hard to predict. Nonmetropolitan areas clearly have enjoyed some favor over metropolitan areas during this decade, part of the desire to spread out. At the same time, some cities report a new interest in city living. Since some of our older city centers have been substantially depopulated, renewed preference for the city would not simply displace present residents. The result would be landsparing.

Other special use categories do not compete for cropland in a major way. A growing category is parks, game refuges, and wilderness preserves. While some wildlife refuges may compete for potential cropland, most of the other special uses do not. Nearly two-thirds of the wildlife refuge area is in Alaska (the Alaskan acreage stands to be greatly enlarged), and only a few million acres elsewhere preempt possible cropland. Likewise, most of the Department of Defense and park and wilderness lands are in the arid or mountain West and do not take potential cropland. Concern over the development of resource values on federal lands because of restricted entry is focused on potential mineral, timber, and grazing output rather than on crop potential, there being very little such potential.

Land Speculation

Rural land, both cropland and other, is serving another function at present that is not well recorded in the statistics; it has become the national security blanket. Until recently we have satisfied the urge to own property with home ownership, but recently rural land has become the focus of a great deal of this motivation.

The reasons are complicated. Farmland has proved a very good speculation, its value doubling between 1971 and 1976 (USDA 1976a). Of course, speculations are self-justifying as long as they last. Coming at a time when the stock market has been sluggish and other investments unspectacular, the land boom has drawn much mobile capital. But there is more to it than that. To many who seek something tangible and enduring in the face of endless inflation, land has seemed a secure hedge. Others, disturbed by the malaise of the cities and frightened by resource and environmental doomsayers, have sought asylum in rural land ownership. Even our more phlegmatic citizens may have a residual land mystique in which rural pursuits are seen as more stable and worthy, even though they cannot be immediately indulged; land ownership is a downpayment on the dream.

This flow of largely city money on what seems a rather large scale is certain to have effects on the rural economy. We know too little about this. Not only cropland but range, forest, and recreational lands are affected. If the remote owners put their holdings to active use, this trend may actually be invigorating; it could bring capital and initiative where both were lacking. Or, if they are able and willing to rent out their holdings to active managers, the impacts may be small. It is the idling of land as the toys of urban dwellers that seems the major threat. The fractured pattern in which land is passing into such ownership discourages active management and frustrates land planners. While the large holdings of absentee owners presumably are bid for in the rental market, the small acreages are less apt to be sought.

Another major impact is through the effect of this bidding on land values. Rural land values in many areas have ceased to be related to their productive potential in agriculture or forestry or to their development potential. Every holder becomes a speculator and has much of his capital unproductively tied up in land. How strong is his incentive to improve or protect the productive value of the land when its price is increasingly divorced from its

productivity? This could retard the development of new cropland, for in addition to the normal risks of conversion there is the large risk that the speculative value of the land will collapse—a risk that could easily swamp gains from conversion.

Land Use Criteria for the Future

While some of the interest in holding rural land is speculative and some is an inflation hedge, part of it is grounded in fear about where our technological society is taking us. That includes a concern about the land, that it is being stripped, clear-cut, eroded, poisoned, paved, drained, and developed but that no one is really watching over it and looking out for it. There is a sense that whether we use it or not, we still want to know that it is there in all its variety and still potentially productive. When we feel it is not being protected and that society has otherwise lost its way, one reaction is to clasp a bit of soil to oneself.

Much of the malaise about land use is related to an instinctual distrust of the concept of land as simply a commodity like any other. We feel a communal interest in the health of the land that derives from awareness of its enduring nurturing role—the mother earth syndrome. The idea of stewardship in which a present owner has obligations toward others and a present generation to future generations in the management of the land, while not frequently articulated, is widely held. Moreover, we are all accustomed to deriving certain unpaid benefits from the land if no more than the aesthetic pleasure from a landscape.

But we are ambivalent. The communal and stewardship attitudes compete with the aspirations of individual owners to maximize their returns from ownership. Private rights are deeply embedded in law and attitudes. Still, there is a growing sense that when the economic criterion is given primacy, many desired values from the land do not survive. Because land is a finite and potentially eternal resource on which other economic activity must rest, the community interest in its deployment and preservation seems paramount.

Although there has been much recent interest in land use controls, we have been slow to define the objectives of such controls or the public purposes they are to serve. Too often land use regulation assumes the character of benefiting some at the expense of others, with the public purpose barely discernible. If there is to be public intervention, the social rationale should be apparent and enjoy wide agreement. At present we have little agreement on the goals.

As a first step toward social consensus we might try to identify those physical or social imperatives to which land use must respond. These would include both some environmental and some resource parameters. Since truly long-range resource needs are not foreseeable, a prudent course would assume they will be no less than at present. Therefore, one aim would be to meet current demands for output consistent with current environmental standards in a way that does not irreparably damage future environment or productive capacity.

That aim is the essence of much conservationist thinking. For example, it is not antiproduction, but it seeks to preserve the productive base. It would support erosion control programs as essential to long-term productivity and to the maintenance of environmental standards, and it would be land sparing.

I am not convinced that agricultural land requirements and demographic trends are on an early collision course, but it still seems wise to give more serious attention to land-sparing urban forms. We may want to do that for other resource reasons. For example, the energy crunch is new and not yet fully reflected in behavior; ultimately it may favor more compact cities. Or preferences could change, favoring the city over suburban sprawl, even though present population growth probably does not compel this as a means of preserving agricultural land. Even so, urban planning could take greater account of the desirability of preserving prime land. Since many urban areas are surrounded by a variety of lands, and the nearby forest and pasture is seldom very productive in those uses, growth could be focused on those areas while saving farmland. Admittedly, the bypassed farm operation would face many problems (Otte), but preserving such land in large blocs could alleviate some of them. Cropland is in great demand for development because it is desirable—clear, well drained, and of moderate relief. It is not insatiable urban growth but simple economic demand (much cherished by farmers) that moves adjacent farmlands into urban use.

A land-sparing policy need not be confined to urban areas. All forms of human activity could be concentrated to a greater degree or lands best suited to them through improve

cultural or management practices. This was already discussed in the case of forest lands. For grazing lands, range improvements would greatly increase carrying capacity while sparing more fragile lands. It is quite likely that further attention to agricultural technology will permit us to maintain output and environmental standards while concentrating production as was done in the past. (Of course, at some level, foreign demand could swamp all other forces.) In general, a land-sparing approach should appeal to those who are interested in maximum preservation of wetlands and wild areas, since it would permit human needs to be met from the smallest acreage while keeping much of the natural system in the ecological bank. Such decisions should not be made on pure efficiency grounds, although they can be informed by economic and social analysis.

If we are to respond to physical or social imperatives, we will have to do so not by private actions alone but through public processes. These may include education, moral suasion, and regulation or acquisition.[6] In combination, they will greatly modify the old perception of land as a commodity. That concept was never held in pure form in any case, and historically it is a modern aberration. It was suited to the task of occupying an empty land in a situation where relatively homogeneous uses prevailed. But our denser pattern of use, more powerful technology, and growing diversity of aims is not compatible with unrestrained private use.

We now place numerous restrictions on private land use. The most obvious reason is to minimize the external consequences of such use. These consequences may be of the simple upstream-downstream variety, or they may involve remote and tenuous linkages. Or we may impose restrictions for planning convenience, especially in an effort to minimize the cost of public services. In other cases, restrictions are aimed at providing or defending public goods; air pollution regulations surrounding a national park would be an example. In all of these cases (except possibly the last) something identifiable in economic terms is being sought and the rationale would be made on those grounds.

Some land use decisions are irrevocable in character and require ethical judgments of the society, others are of less import. If we are to act responsibly, we will harken to the ethical imperative and thereby will be restricted in our range of choice. Public decisions will be required to defend the public purpose. Other decisions allow more latitude in outcome, but because of the prevalence of externalities they still require public choice. In this area of planning and regulation where there is room for the expression of preference, we need improved techniques of public choice. The aim is a model that is less arbitrary, more open to all participants, and more equitable in its results. There is no right answer. Welfare economics may be of some value by proposing reciprocal compensation between winners and losers in the process, or we might look to an ethical model as per Rawls or to a political trade-off model as sketched by Haefele.

It is important to know when to apply these decision models. We may have great latitude in deciding whether to favor private or common space in the city, but the time might come when there would be less latitude in deciding how much land of what kind can be spared for cities. The decision to preserve a major share of the natural system is essentially an ethical choice and should not be seen as simply a matter of arbitrating preferences (Leopold). For that decision we need a vision—a land ethic that allows space for ethical values because it properly organizes other human activity.

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Farm Labor Markets
(Ben C. French, University of California, Davis, Chairperson)

Emerging Issues in Agricultural Labor Relations

Philip L. Martin and Refugio Rochin

Labor relations in agriculture have been characterized by the absence of formal agreements negotiated by employer and labor representatives. Historically, labor law has assured agriculture a "special and exempt" status, a condition obviating any legal responsibility for employers to respond to employee demands, making organizing efforts more difficult. The hired farm work force found self-organization nearly impossible. Despite periodic resurgences of interest in the agricultural labor problem associated with the periodic "rediscovery" of migrant farm laborers, the extension of minimum wages and, more recently, unemployment insurance to farmworkers, and the proper role of alien labor in American agriculture, agricultural labor relations within a defined legal framework are a product of the mid-1970s.[1] The 1975 passage of the Agricultural Labor Relations Act (ALRA) in California, the state with the largest hired work force, marks a new era in agricultural labor relations.

A system of labor relations is usually defined by the actors or participants in the process (e.g., employers, workers, and government), a context or framework within which the participants interact, and a body of rules that govern participant behavior in the course of negotiating and interpreting labor agreements. The identification of participants, frameworks, and rules implies a sense of formality and continuity, attributes uncharacteristic of past labor-management interactions in agriculture. The fact that an orderly system of labor relations is just emerging forces an analysis of two related issues: factors giving rise to unionism and bargaining, i.e., the existence of unionism and the share of the agricultural labor force that is organized, and factors shaping the direction and content of labor relations, i.e., the type of labor-management relationship that evolves.

This paper explores salient aspects of current labor relations in agriculture and erects a framework for predicting the course of future labor-management interactions. After exploring the impacts of agricultural structure and labor force composition on the functioning of the agricultural labor market, the evolution of public policy that culminated in California's ALRA is described. Predictions about the existence and shape of agricultural labor relations are made within the framework of structural, composition, and public policy influences, and it is suggested that the ability of the competing employers and unions to secure favorable public intervention will be as important as raw economic power for achieving partisan goals. Although data are drawn from national sources, we conclude by noting that agricultural labor relations are most likely to be confined to the labor-intensive fruit and vegetable sectors in the South and West.

Labor Relations Systems

The study of labor relations encompasses the nexus between fundamental productive forces in society. It describes the intersection of entrepreneurial interests in production and profit, worker interests in economic welfare

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Philip Martin and Refugio Rochin are assistant professors in agricultural economics, University of California, Davis.

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[1] Hawaii's labor relations statutes have covered agricultural labor since 1945 and Wisconsin's labor legislation was construed to include agricultural laborers in 1967–68 (Martin). Four states, Idaho (1972), Arizona (1972), Kansas (1972), and California (1975), currently have agricultural labor relations statutes. For a comparative analysis of the legislation in these four states, see Kozlara.

and dignity, and the public interest in ensuring prosperity and stability. In the American context, labor relations have historically been confined to the resolution of competing interests in the private sector, with government existing primarily to determine the "rules of the game" or framework that bound permissible private actions. The recent evolution of labor relations in America has altered this two-factor model: government now intervenes to alter both the outcomes of the bargaining process (because of macroeconomic conditions) and the negotiation process itself (because of, e.g., civil rights concerns).

The system of labor relations that evolves in each industry or occupation depends on three (sets of) interdependent factors. The structure of the industry and the composition of the labor force govern the operation of the labor market, the institution for matching labor demands and supplies. Individuals and traditions in each sector influence the type of labor relationship that exists, from cooperation and renouncement of strikes in the steel industry to more persistent strife in longshoring. Finally, public policies influence labor relations both directly and indirectly. In addition to specifying duties and permissible activities within a defined legal framework, public policies affect labor markets through social welfare policies, immigration policies, and taxing and spending policies.

Agricultural labor relations are likely to be influenced by these same general factors. The structure of the agricultural industry influences the number, type, and concentration of employees, the extent to which agriculture is perceived as a sector deserving "special and exempt" status, and the degree of uniformity of interest among farmers. The composition of the farm labor force and the attitudes and beliefs of trade union leaders affect the ease or difficulty of achieving and maintaining union organization as well as determining the choice of instruments used to negotiate and enforce settlements, e.g., the choice of strikes versus boycotts. Agricultural structure, labor force composition, and union and public policies combine to determine the structure and functioning of the agricultural labor market. Public policy also exerts more direct influences on agricultural labor relations by specifying the legal framework and providing a forum for legal recourse.

Rather than experiencing the evolutionary growth of public intervention in the processes and outcomes of industrial relations, agricultural labor relations in California have been marked by a high degree of public input from the outset. Public intervention in agricultural labor relations reflects, in part, the increased acceptance of intervention in labor-management relations, but it also illustrates the need for guidance in a complex and diverse sector characterized by a variety of possible bargaining units, a fluid work force, and a need to define rights of access and property rights when residences and businesses merge. The degree of public input induced by this complexity means that competing farmer and worker interests will bargain in both public and private arenas, with success in the public rule-making process crucial for determining subsequent private bargaining outcomes.

The Agricultural Labor Market

Agricultural labor is performed by three distinct groups. Farm operators, numbering about 2.5 million in 1974, do most of the agricultural work. Farm operator labor is supplemented by nearly 0.5 million unpaid family workers and an estimated 2.7 million hired farmworkers (USDA).[2] Since labor relations are largely confined to the hired farm workforce, attention is directed to the number, characteristics, and distribution of such workers.

The hired farm work force, about 3% of the civilian labor force, is distributed unevenly across crops and, given their spatial concentration, across geographic areas. Although man-hour distributions may not indicate the allocation of farm laborers because of variance in hours worked, only man-hour labor breakdowns are available for crop groupings. In 1975, 2.9 billion man-hours of (self-employed and hired) labor were required for the production of crops in the United States, nearly 55% of all hours used in agriculture.[3] Three labor-intensive crop groupings, tobacco, vegetables, and fruits and nuts, accounted for 38.8% of all crop hours in 1975, even though their sales

[2] Four federal series on agricultural labor are available. For a discussion of the concepts and shortcomings of each, see Holt et al.

[3] In 1975, a total of 5.3 billion man-hours of labor were used in the production of crops and livestock. If every person in agriculture had worked "full-time" (40 hours per week for 50 weeks), a total of 2.6 million workers would have been required. The 2.7 and 2.9 million estimates reflect only hired workers; a further 2.2 million persons self-employed in agriculture were aided by 423,000 unpaid family workers in 1974 (U.S. Dep. Commerce).

value was only 12.4% of all crop sales (USDA). Since labor relations are defined by the interaction of groups of workers and management, most union activity occurs in those labor-intensive crops that bring together groups of workers for periods of peak labor demand, i.e., the harvest.[4]

The nature of agricultural production concentrates hired farm labor on particular types of farms at specific times of the year. The distribution of crops are in turn consolidated in particular geographic areas, permitting identification of potentials for labor relations merely by examining the spatial distribution of crop types. In the Pacific region, for example, 78.4% of all man-hours necessary for crop production in 1975 were used by growers of vegetables, fruits, and nuts. Thus, the nature of labor demands and the concentration of labor-intensive crops ensures that pressures for labor relations are limited geographically and that actual employer-employee interaction is of limited duration in any growing season.

The nature of labor-intensive crop production and the characteristics of agricultural products combine to define some well-known aspects of agricultural labor markets (Fisher). The temporal and spatial concentration of the demand for labor assures the need for a hired labor force, but the fact that labor demands peak for a harvest typically lasting less than two months forces either the availability of a reserve labor pool for agriculture, e.g., housewives or students not normally in the (agricultural) labor force, and/or a harvest labor force that can migrate from one crop harvest to another. The multiplicity of heterogeneous growers permits a variety of economic and institutional factors to influence labor demands and hiring practices, from individual recruitment efforts to reliance on public employment services or simply utilizing farm labor contractors or union hiring halls.

Although farmworkers find work in a variety of ways, agricultural wages are far more uniform. Traditionally, grower groups recommended piecework rates in their annual winter meetings, which became standard for a particular crop in the following year. Since a relatively large fraction of the seasonal work force is new each year, wage bonuses are not typically paid to returning harvest workers; veteran farmworkers are not even assured priority in hiring. The "impersonality and insecurity" inherent in the hiring-wage payment system were recognized as early as 1939 by witnesses before the La Follette Committee (U.S. Congress, Senate) and repeated in the report of the President's Commission on Migratory Labor. With piecework wage rates shifting the efficiency burden to harvest workers and because relatively little skill is necessary for most harvest jobs, employers had few incentives to foster the creation of a stable recruitment and hiring system.

The hired farm work force is a heterogeneous lot. Demographically, most hired farmworkers (1975) are white (72%), male (75%), have nonfarm residences (79%), and are nonmigratory (93%). Until Spanish-surnamed persons were separated from whites, the hired farm work force was becoming whiter, as black laborers exited agriculture in the South. Males with nonfarm residences have long comprised more than 70% of the labor force, but the importance of youth has been increasing; today, nearly two of every three hired farm workers is under 25.

The hired farm work force exhibits both demographic and participation heterogeneity. Most hired farmworkers (65%) work less than three months in agriculture, while fewer than one in six work "full-time," i.e., more than 250 days per year. Agricultural labor relations are largely confined to the seasonal hired farm work force, working at least three months each year. Regular or full-time workers are spatially dispersed (even a large farm rarely has more than three or four full-time workers), while the extremely casual labor force, in farmwork less than 25 days per year, has few incentives to pay union initiation and membership fees. If seasonal farmworkers are defined as those working between 25 and 150 days in agriculture, this seasonal component comprised 34% (911,880) of the 1973–75 average work force (Rowe and Smith).

California's hired farm work force is assumed to differ from the national farm work force in several important respects.[5] Seasonal farmworkers have long been more important in California, since specialty crops require preharvest, harvest, and postharvest attention. Ever larger farms and increased mechanization seem to have altered the compo-

[4] Although tobacco harvesting results in concentrations of hired farm labor, formal labor relations in agriculture are unlikely to result in tobacco production because of its location in the Southeast, the practice of exchanging labor among small growers, the dominance of youth in the labor force, and the availability of a mechanical tobacco leaf harvester.

[5] The last detailed profile of California's farm labor force was done with 1966 data (California Assembly).

sition of this labor force, increasing the relative importance of housewives and youth, but peak labor demands are still met by the longer term seasonal labor force. This longer term seasonal component of the labor force has been successful in initiating unionism and bargaining and has succeeded in establishing a public policy toward farm labor in California.

The Emergence of Agricultural Labor Policy

Agriculture, the dominant sector in every society during initial stages of economic development, has always experienced government intervention. In the 1920s and 1930s, public intervention in output markets and nonlabor input markets occurred, the former setting target or minimum prices and the latter assuring credit, electricity, and cooperative opportunities. The special status conferred on and imposed by farmworkers that the hired laborer position was only a transitory way station to farm ownership permitted employer interests to exclude agricultural labor from much of the social welfare legislation initiated at the same time (Morin). Despite public intervention at other junctures, agricultural labor was excluded from legislation because of its "peculiar features," including the seasonality of employment, labor migrancy, the perishability of agricultural crops, and the competitive output markets faced by farmers.

Efforts to promote the integration of agricultural labor into the larger social fabric were not absent. Several studies demonstrated the extent to which (California) agriculture was more like industry than merely a collection of family farms. McWilliams documented the extent to which California farms were merely "factories in the field," while Jamieson identified numerous attempts to organize the hired farm work. These organizing efforts, often spearheaded by nonfarm groups, failed to secure stable agricultural labor relations.

The early 1960s witnessed the rise of ethnic-based unionism among Filipino and Mexican farmworkers in California. Cesar Chavez was able to combine the AFL-CIO's Agricultural Workers Organizing Committee with his own National Farmworkers Association to form the United Farm Workers Organizing Committee (UFWOC) in 1967. The events surrounding the passage of civil rights legislation in 1964 heightened awareness of ethnicity and equality, permitting the UFWOC to integrate both economic and sociopolitical concerns into its organizing drives.

California's agricultural labor relations during the 1965–75 decade were marked by the instability characteristic of the past. This time, the farmworkers succeeded in securing enough outside assistance to assure a permanent organization. Continued pressures forced legislative hearings on agricultural labor problems, with the growing realization that some type of farm labor legislation was inevitable. Initially, employer antagonism and a lack of legal redress were primary union concerns; later, interunion rivalry between the (renamed) United Farm Workers Union (UFW) and the Teamsters, who secured fieldworkers contracts to complement their cannery and transportation membership, increased public awareness of the farm labor issue. The UFW engaged strategies and tactics common in pre-1935 industrial relations, including secondary boycotts of businesses selling nonunion and rival union products, the elicitation of public sympathy, and attempts to channel demands through political channels.

In 1975, California passed its Agricultural Labor Relations Act (ALRA). Prior to the ALRA, Fuller noted:

> farmworkers were being forced into one union or the other without the exercise of self-determination; farm employers were being forced to choose one of three options: to resist unionization, to capitulate to coercion, to engage in collusion. None of these choices brought tranquility to the parties involved or to the community at large. To the contrary, the numerous frictions involved were regularly disruptive and occasionally bloody (p. 72).

The ALRA was viewed as necessary to restore tranquility and ensure agricultural production.

The ALRA, modeled after the National Labor Relations Act, created an Agricultural Labor Relations Board (ALRB) to supervise and certify farmworker elections. Certification petitions, normally filed by employees or labor organizations, are the basis for ALRB ordered elections. To maximize the participation of seasonal and migratory workers, elections can be held within 48 hours, although the ALRB is allowed up to seven days between petition and election. To ensure participation, petitions must be filed when the number of employees is at least one-half the employer's peak agricultural employment in the current calendar year.

Under national labor statutes, the National

Labor Relations Board (NLRB) is given some license in determining appropriate bargaining units. A labor organization selected by the majority of employees in the defined bargaining unit is entitled to exclusive recognition as the unit's labor representative. The ALRA defines the appropriate bargaining unit to include "all agricultural employees of an employer,"[6] precluding the formation of separate units based on craft or departmental community-of-interest considerations or distinctions between seasonal, migrant, and full-time workers.

Determining eligibility to vote is a major issue in the face of the casual labor force that dominates agriculture. Since a majority of all hired workers do less than 25 days of farmwork each year, an equal weighting of votes would give those with only a casual attachment to farmwork the same voice as those most dependent on farmwork. The ALRA declares that "all agricultural employees of the employer whose names appear on the payroll applicable to the payroll period immediately preceding the filing of the petition . . . for an election should be eligible to vote" (*California Labor Code*, sec. 1157). Problems arise because of (*a*) differing modes of payment, e.g., daily, weekly, and biweekly payrolls, (*b*) the eligibility of strikers, especially when the striker is only a casual worker, (*c*) the eligibility of workers in second or runoff elections after they have, e.g., already moved on to a new employer, and (*d*) the eligibility of those on temporary layoff, because of, e.g., bad weather or slow crop ripening. Those issues, illustrating the administrative complexity inherent in any agricultural labor relations statute, have yet to be resolved in California (Grodin).

When disputes arise, the ALRA has attempted to limit the range of recognition and impasse resolution instruments. The UFW successfully used the boycott to gain recognition and force settlements at its inception, and the ALRA is cognizant of the importance of boycotts, permitting the union to picket and discourage purchases from those handling nonunion products if the union has been certified as bargaining representative for the primary employer's labor force. If a union is attempting to organize a group of unorganized workers, the union may distribute information to (but not picket) a secondary employer. If bargaining fails to produce a settlement, conciliation is available but not required. Harvest strikes, always a contentious issue, are not restricted by statute.

The ALRA had an uneven beginning. After only six months, funds were exhausted, and ALRA opponents succeeded in denying funding from February 1976 until July 1976. After the defeat of proposition 14 on the November ballot, which would have made funding for the ALRB a constitutional mandate and given organizers easier access to farmworkers on grower property, the ALRB began "normal" operations with the opening of field offices in December 1976. In February 1977, the Teamsters agreed to halt their fieldworker organization drives, leaving harvest labor's representation to the UFW (Rochin).

Contemporary Issues

Formal labor relations in agriculture are a result of the erection of a labor relations framework that provides a forum for dispute settlement and a mechanism for redress. In light of the severe contractions in UFW membership in the period prior to the ALRA, the union's survival has been remarkable. As the dominant union active among agricultural fieldworkers, UFW strategies and successes will shape the future of agricultural labor relations in both California and in other states.

Several sets of issues remain unresolved. The immediate problem is the formulation of specific labor policies in a heterogeneous agriculture, including the definition of bargaining units, the determination of voter eligibility, the timing of elections, the rights of union organizers, and the timely resolution of objections. Until precedents are established, adversaries will have incentives to litigate, since the outcome before the ALRB remains in doubt. The ALRB itself, hampered by personnel turnover as well as a need to hire and train personnel, requires time to gain consistency and self-confidence.

Longer term issues center on the impacts of a changing agricultural structure and social welfare policies on the structure and functioning of the agricultural labor market. The structure of labor-intensive agriculture in the West could be quickly altered if persistent water shortages led to "full pricing" of state and

[6] The ALRB is permitted to exercise its discretion in defining bargaining units when "the agricultural employees of the employer are employed in two or more noncontiguous geographic areas" (*California Labor Code*, sec. 1156.2).

federal irrigation waters, since fruits and vegetables are both water intensive and time intensive, requiring labor to nurture and harvest. Enforcement of the 160 acre limitation on farms receiving federal water could encourage a shift toward labor-intensive fruits and vegetables, since large acreages capable of using capital-intensive equipment would no longer be as profitable.

Trade and immigration policies affect the agricultural labor market by altering demands for labor. As Mexican irrigation systems expand and as the real cost of transporting agricultural commodities between the United States and Mexico and the Orient declines, the production of labor-intensive products may shift to countries with lower labor costs. Such moves are accentuated or impaired by tariff and quota policies with respect to agricultural products. If barriers to importing agricultural products are erected and farm wages rise, the incentive to (illegally) enter the United States increases, making immigration and trade policies mutually dependent and imparting another source of instability to agricultural labor relations.

Just as trade and immigration can affect the number and focus on farm labor jobs, so do continued prospects for mechanization and labor displacement in agriculture. Agricultural mechanization efforts, concentrated in labor-intensive sectors, are less predictable than changes in trade or immigration policies, allowing growers to use mechanization as a threat in bargaining. Unless unions extract negotiation or compensation rights to govern the introduction of labor-saving technology (Martin and Johnson), possible mechanization will inject another element of uncertainty into the agricultural relations system.

Trade and immigration policies, water prices and acreage limitations, and innovation development and diffusion are directly or indirectly influenced by public policies, affecting the structure and processes within agriculture and thus the operation of agricultural labor markets and labor relations. Labor and manpower policies directly affect the size and composition of the labor force as well as the mode of labor relations. In addition to the labor relations law, public policies toward minimum wages in agriculture, workmen's compensation, and the extension of unemployment insurance to farm labor affect the type of worker likely to be hired and the need for union-management bargaining over these labor issues. To the extent that agricultural labor is treated as industrial labor and record-keeping burdens are increased, employers may have incentives to hire more native males and fewer aliens, youth, and females. As income security programs expand, the size of the hired farm labor force may decrease, leaving fewer casual workers with low labor force and union attachments. Pesticide and environmental policies affect agricultural labor relations by transforming one aspect of bargaining from private to public forums, although this translation often produces employer-union solidarity, as in the automobile industry. Thus, labor and social policies will affect future agricultural labor relations by directly erecting and altering the bargaining framework and by indirectly affecting the issues to be negotiated as well as the size and composition of the labor force to be bargained for.

Labor relations in any industry are a product of both general trends and policies and the unique characteristics and individuals in each industry. Agriculture is a complex, heterogeneous industry imbued with antilabor traditions. The "lateness" of the advent of labor relations in agriculture has reserved a much larger role for public policy in the formation and direction of labor-management interaction. Public policy, of course, results from the resolution of conflicting claims in public rather than private forums. Farmworkers, experiencing only limited successes privately, have now secured legal frameworks for initiating labor relations in several states. As in most situations where a dominant party must yield to one traditionally excluded, initial experiences have lacked stability and predictability. But, after the resolution of short-term initiation problems, agricultural labor relations promise to achieve a degree of stability at least congruent with the stability of agriculture.

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Emerging Issues in Agricultural Labor Relations: Discussion

Collette Moser

The paper by Martin and Rochin is a combination of an historical account of the development of labor-management collective bargaining in agriculture in the United States, the current status of collective bargaining in California agriculture, and predictions about changes in labor supply and labor demand in agriculture. Sometimes the predictions refer to labor supply and demand changes in response to collective bargaining; sometimes collective bargaining is itself a response to labor supply or demand changes; sometimes the connection between the predictions and collective bargaining is unclear.

My discussion is organized around four models that one often sees in the literature of labor economics and labor relations. These models are as follows: (*a*) a comparison of the situation of the unionization of workers in relevant industry (agriculture) with unionization of workers in another industry; (*b*) analysis and predictions of the outcome of unionization of workers in an industry based on information on changes in another policy area (for example, it is not unreasonable to predict what will happen to agriculture workers with changes in labor-management relations laws in view of changes in protective labor laws that affect agriculture); (*c*) a comparison of unionized workers in an industry, sector, or geographic area with nonunionized workers in that same industry but in a different sector or different area (for example, one might compare unionized agricultural workers in California with nonunionized workers in the Midwest); (*d*) economic theory used to predict various effects of unionization of agricultural workers.

The paper contains observations on the development of collective bargaining in agriculture that point out some special characteristics of unionization of agriculture that appear to differentiate agriculture from other industries. Most notable of these is the lateness with which legislation for effective systems of collective bargaining has come to this industry. However, legislation for collective bargaining for hospital workers and state and local employees has also been late, and there are groups of workers such as household domestics that are less unionized than agriculture. It is not clear whether the authors accept the concept that agriculture's features of seasonality, labor migrancy, perishability of crops, and competitive output markets are "peculiar." In any event there are other industries such as construction and longshoring that have comparable characteristics.

Martin and Rochin discuss in detail certain features of collective bargaining as it is emerging in California agriculture that appear to differentiate it in "the formulation of specific labor policies . . . , including the definition of bargaining units, the determination of voter eligibility, the timing of elections, the rights of union organizers, and the timely resolution of objections." However, these problems have been confronted and resolved in other industries and, here again, comparisons with longshoring and construction are relevant. In fact, in some construction cases the problems of tracking down workers for a runoff election may be even more difficult since the worker may not expect to work for that employer again. In any event these are organizational problems that the union faces and if the union is sufficiently strong it will overcome them.

Moreover, the national legislation governing the holding of representation elections outside of agriculture is also being questioned. Recent proposals by President Carter and Secretary of Labor Marshall to amend the National Labor-Management Relations Act speak to problems faced by some unions, particularly textile workers in the South, in their organizational efforts (*Nation's Business*). The anti-labor traditions in agriculture are probably no worse than those in some other industries that have had much larger corporate finances for "union busting."

Collette Moser is an assistant professor in the Department of Agricultural Economics, Michigan State University.

The authors suggest that the role of part-time workers in farm union elections is a unique and negative one. Other unions also have a predominance of part-time workers and are able to survive. In fact, this feature, as well as the youthfulness and turnover of the agriculture labor force and the availability of a reserve pool of workers such as housewives or students, are also features of much retail employment that is unionized.

While Martin and Rochin appear to be arguing for removal of part-time workers from representation elections, protective labor legislation, as it is being applied to agriculture, appears to be going in the opposite direction. Instead of narrowing the concept of a "worker," public policy is making workers in more industries and employed by smaller employers eligible for unemployment compensation, worker's compensation, and minimum wages.

Moreover, the effects of the extension of protective labor laws to agriculture on employer preferences as to "native male, aliens, youth, and females" are not necessarily homogeneous. For example, unemployment insurance extension may actually increase the demand for youths because since they return to school they are ineligible for benefits.

In fact, proposed increases in minimum wage laws, particularly those that tie automatic increases in the minimum wage to increases in the average hourly wage in manufacturing, may actually be more significant than collective bargaining in determining labor supply-demand adjustments. These proposals are not discussed in this paper.

Based on economic theory, the authors predict an increase in mechanization in response to unionization. In the Midwest, great mechanization has taken place without the threat of unionization. Mechanization is used to lower unit costs, labor being only one of these. In order to determine that unionization "causes" mechanization, one must assume that the union will have a strong effect on wages, that is, that wages will increase by a greater amount than they would in the absence of the union. However, as Marshall carefully concludes, it is unlikely that a union of unskilled agriculture workers will have such an effect on wages (p. 162).

On the other hand, the authors assert that "enforcement of the 160 acre limitation on farms receiving federal water could encourage a shift toward labor-intensive fruits and vegetables. . . ." Based on experiences in the Midwest with its smaller farms, such a shift from capital to labor-intensive production seems unlikely. In many cases farmers would custom-hire equipment.

Martin and Rochin also predict a shift toward "more native males and fewer aliens, youth, and females" as a result of increased costs of record keeping. I assume that the prediction is based on an expected greater productivity of native males relative to aliens, youth, and women and the assumption that the wage rates for all groups would be the same. While the latter condition is unlikely, the former condition may also not be so. Aliens who are often worried about keeping their jobs may actually work harder and women according to a recent report may actually cost less because "men are most likely to cause . . . discipline problems, especially those arising from drug and alcohol abuse" (as stated in the *Chicago Tribune*, p. 1).

In conclusion, Martin and Rochin have tried to distinguish between private and public labor relations in agriculture. The passage of farm labor relations laws in California and a few other states represents the "public policy era." To me situations outside of agriculture comparable with this model would be pre- and post-1935 Wagner Act periods. Before collective bargaining had the legitimacy of the Wagner Act, it was a public activity and there were public policies toward it. I submit the same is true of agriculture. For instance, whether injunctions are or are not used against strikers, picketers, etc., represents the implementation of public policy even in the absence of direct labor legislation.

What we are witnessing then is not a shift from the private to the public arenas but a movement along a continuum of public policies. If the movement parallels events in other industries, it will evolve into full coverage of agriculture workers under all protective labor laws and under the National Labor Relations Act.

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Interactions Between Farm and Nonfarm Labor Markets

Wallace E. Huffman

During the past 25 years, rural areas in the United States have undergone some dramatic changes. The most fundamental and pervasive forces behind these changes have been technological advancements in agriculture and economic growth (i.e., growth in real income per capita). This paper is concerned with the interaction of farm and nonfarm labor markets. The time horizon is the past 25 years, roughly since 1950. I shall highlight some of the significant long-term changes that have occurred in these labor markets and then discuss policy implications.[1]

A Framework for Viewing Interactions

During the past 25 years, the most fundamental and pervasive factors affecting the interaction of farm and nonfarm labor markets have been economic growth and technological change. The per capita income elasticity of demand for farm products is (and has been) positive but less than one, so the income elasticity of demand for nonfarm products is larger than one. Thus, domestic growth of real per capita income has caused a more rapid rate of growth of domestic demand for nonfarm products than for farm products. Furthermore, differences in rates of growth of domestic demand have increased as the rate of population growth has slowed. If the supply curve for domestic farm products shifts at least as fast as the supply for nonfarm products, the farm output share of national income and the relative farm output price must fall, provided that foreign demand growth for U.S. products is not offsetting.[2] Even if technical change was so favorable to agricultural labor as being factor neutral and at equal rates in both sectors, the income elasticity differences imply that growth of labor demand in the nonfarm sector exceeds the farm sector. If both sectors initially have equal rates of population and labor supply growth, the relative farm-labor wage rate must fall.

For labor to be fully employed and farm labor to earn its opportunity return under these conditions, a net transfer of labor to the nonfarm sector must occur. Wage rates become more equal, and they may approach equality when allowance is made for living cost differences and an opportunity return on moving costs. The geographical dispersion of agriculture as an industry and its rural location away from most, but not all, other industries increases the costs of obtaining information about nonfarm jobs and the probability of household mobility for persons to switch industries.

The transfer of labor occurs in three major ways. First, families may sever farm sector ties by quitting farm jobs, selling any farm capital they own, and taking a nonfarm job, perhaps moving to a city. Second, as children come of age, they may leave agriculture and take nonfarm jobs, but their parents remain in farming until retirement. Third, workers and their families may stay on farms, but some family members take full-time nonfarm jobs (e.g., wife) while others (e.g., husband) continue full-time work. Or some members may reduce their hours of farm work, take a nonfarm job, and become multiple jobholders. The relative attractiveness of these alternatives depends on the location of nonfarm job opportunities, the types of skills of the people, and the costs of commuting or of moving to nonfarm jobs. All have been important sources of adjustment.

Wallace E. Huffman is an assistant professor of economics, Iowa State University.

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[1] Johnson also discusses some of these changes. Others may consider that some significant changes have been excluded.

[2] All (own price) demand elastitities are assumed to be negative, and all (own price) supply elasticities are assumed to be nonnegative. Production functions for both products are assumed to be homogeneous of the same degree.

If, with growth, the real wage rates rise in the nonfarm sector as they have in the past and enough labor moves out of the farm sector so the real wage rate rises there, too, new labor-saving technology may be induced for agriculture. This process is elaborated on by Binswanger. His results suggest that induced innovation has occured in U.S. agriculture and that it has been labor and land saving. Also the population and labor supply growth rates may initially be larger in the farm than in the nonfarm sector as a result of the higher birthrates of farm women. Both these changes increase the net transfer of labor services required to equalize earnings between sectors while maintaining full employment.

Economic growth has led to other changes that have enhanced the interaction of farm and nonfarm labor markets and eased the labor market adjustment. The expansion of communication systems (free mail delivery, telephone service, radio, and television) to rural areas greatly increased the access of rural and farm people to ideas and knowledge. The cost of rural transportation has fallen with the improved quality of rural and urban roads and improved quality and falling cost of automobile services. The rising education levels of farm and nonfarm populations have increased the supply of allocative ability and the ability to perceive and respond to changes in economic conditions (Schultz) and have increased general skill levels. But educational level differences between the farm and nonfarm population, whites and nonwhites, and the South and the rest of the United States are sizable and are narrowing slowly. The reduced cost of transportation and communications and increased education levels have decreased the transactions cost of resource adjustment and have enhanced the efficiency of resource allocation between rural and urban labor markets.

Long-Term Changes

Farm-Nonfarm Income and Population Changes

During the early 1950s, the income position of the farm population deteriorated relative to the nonfarm population; since then it has improved markedly. Average per capita disposable personal income of the farm relative to the nonfarm population was 55.1% in 1950, falling during the early 1950s to about 45.7% in 1956 (USDA 1976).[3] Since the mid-1950s, the relative income position of the farm population has steadily improved. In 1970, the ratio of farm to nonfarm real disposable personal income was up to 75.5%,[4] and in 1975 up to 87%. Thus, the income position of the farm relative to the nonfarm population has improved dramatically. This period of improving relative income position of the farm population coincided with a marked decline of the farm population size.

During 1950–70 there was a massive net movement of whites and nonwhites off farms and into the nonfarm population and labor market. The result has been a reduction of the farm share of the total population from 15% in 1950 to less than 5% today. For whites, the percentage reduction between 1950 and 1960 was 40% and between 1960 and 1970 was lower, 18%. For nonwhites, the movement off farms between 1950 and 1960 was more dramatic, exceeding 50%, and it was a slightly lower 47% between 1960 and 1970.

There were, however, large regional differences in the rates of population change. The West and the South have had the largest percentage increases in the nonfarm population (table 1). For the farm population, the South and Northeast registered the largest net declines between 1950 and 1960, roughly 50% for whites and nonwhites. The North Central region had the lowest rates of decline for whites (27%) and nonwhites (16%) for the early period. Between 1960 and 1970, the North Central region had the largest reduction in the white farm population (45.5%), and the South had the largest reduction (52%) in the nonwhite population. The net result of these changes has been a significantly greater concentration of the farm population in the North Central region (an 11.2 percentage point gain) and significantly less concentration in the South (a 13.9 percentage point decline).

The movement off farms during 1950–60 contributed to an equally rapid growth rate of urban and rural nonfarm populations. The de-

[3] Personal disposable income of the farm population refers to income received by all persons living on farms. It includes the families of hired farm workers who live on farms, but it excludes farm operators and their families who do not live on farms. Before making the relative income comparison, the per capita income of the farm population was deflated by the USDA index of prices paid by farmers for family living items (1967 = 100) and the per capita income of the nonfarm population was deflated by the consumer price index of all items (1967 = 100).

[4] The boom in farm prices and net farm income in 1973 actually pushed the ratio up to 109.4%.

Table 1. Farm and Nonfarm Population Change (Percentage) by Census Regions and Race, 1950–70

Region, Race	Total		Nonfarm		Farm	
	1950–60	1960–70	1950–60	1960–70	1950–60	1960–70
U.S.						
Total	19.0	13.3	30.0	16.1	−41.7	−21.2
	(100.0)[a]	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
White	17.7	7.9	27.6	10.0	−39.9	−17.8
Nonwhite	30.0	55.4	52.1	64.0	−52.2	−46.6
	[10.5][b]	[15.7]	[8.2]	[15.3]	[14.5]	[8.0]
Northeast						
Total	13.2	9.8	16.2	9.8	−49.1	8.5
	(26.2)	(24.1)	(29.5)	(24.9)	(7.8)	(9.3)
White	11.0	4.8	14.0	4.7	−49.0	8.0
Nonwhite	51.7	75.8	52.4	75.8	−54.8	80.5
	[5.3]	[11.3]	[5.5]	[11.5]	[0.9]	[1.2]
North Central						
Total	16.1	13.4	24.9	16.7	−27.4	−14.7
	(29.5)	(28.8)	(29.0)	(28.0)	(32.2)	(43.4)
White	14.0	10.7	22.7	13.9	−27.3	−45.5
Nonwhite	54.5	49.5	57.0	50.0	−14.7	−13.1
	[5.3]	[9.2]	[6.2]	[10.0]	[0.8]	[0.6]
South						
Total	16.5	14.2	38.9	21.4	−50.2	−32.6
	(31.3)	(30.9)	(27.7)	(30.9)	(51.6)	(37.7)
White	22.0	6.7	44.1	10.3	−49.2	−26.3
Nonwhite	−3.2	48.0	18.5	65.3	−53.0	−51.6
	[21.9]	[23.6]	[20.4]	[23.7]	[26.5]	[18.0]
West						
Total	43.4	24.1	52.2	25.9	−36.8	−17.4
	(13.0)	(17.1)	(13.8)	(17.5)	(8.4)	(9.5)
White	39.1	11.2	47.4	12.7	−37.0	−20.3
Nonwhite	125.1	173.1	144.9	178.1	−33.0	27.6
	[5.0]	[17.4]	[5.0]	[17.7]	[5.7]	[9.3]

Source: U.S. Dep. Commerce 1953, 1963, 1972.
[a] Numbers in parentheses in the 1950–60 (1960–70) columns give the regional distribution of the population in 1950 (1970).
[b] Numbers in brackets in the 1950–60 (1960–70) columns give the percentage of the population in the region that is nonwhite in 1950 (1970).

cade of the 1960s, however, was the period of movement from rural to urban areas. During this period, the growth rate for the urban population was 2.5 times larger than for the rural nonfarm population. Since 1970, signs of at least a temporary reversal of the rural to urban population movement have occurred (Beale). The positive growth is in nonmetropolitan areas both adjacent to and more distant from large urbanized areas. Some of the reasons for this reversal seem to be decentralization of industry, growing population of retired and semiretired individuals, growing rural-oriented recreation industry, and increasing air pollution, crime, and congestion in urban areas.

The Rising Labor Force Participation Rate of Women

A major postwar change in the U.S. economy has been the rising labor force participation rate of women, especially of married women. Between 1950 and 1970, the labor force participation rate of women (married women, husband present) increased from 31% (24%) to 43% (41%), and the increase in number of women in the civilian labor force was a dramatic 85.6%, compared with 18.8% for men (see bottom of table 2). In both farm and nonfarm households, birthrates have fallen during the past 25 years, and households have purchased many new durable goods, some of which are labor saving. Both factors have contributed to a reduction in the demand for wives' household time, releasing time for work outside the household and/or for "leisure" time.[5]

The participation rate of farm resident wives in nonhousehold work also is rising. The level

[5] These factors have also contributed to the leveling out of the labor force participation of women by age; i.e., for recent years, there has not been such a drop in female participation rates during their twenties.

Table 2. Occupational Distributions by Farm Residents (≥ 14 Years of Age) in Civilian Labor Force

Occupational Categories	Percentage Change[a]			
	Males		Females	
	1950–60	1960–70	1950–60	1960–70
Farm residents				
Farmers and farm managers	−49.1	−44.6	−3.1	−45.3
	(56.3)	(38.7)	(8.5)	(4.7)
Farm laborers and farm foremen	−55.5	−49.4	−58.4	−60.9
	(19.1)	(10.4)	(32.1)	(5.4)
Professional, technical, and kindred workers	−19.9	72.1	3.1	31.6
	(1.2)	(4.0)	(10.0)	(14.1)
Managers and administrators, except farm	−25.5	35.0	−11.8	65.9
	(2.0)	(4.8)	(2.0)	(3.1)
Sales workers	−23.3	18.6	5.4	13.2
	(1.1)	(2.5)	(4.6)	(5.6)
Clerical and kindred workers	−16.0	30.0	30.9	71.2
	(1.0)	(2.8)	(10.1)	(23.6)
Craftsmen, foremen and kindred workers	−30.3	47.1	3.9	165.6
	(5.5)	(13.7)	(0.7)	(2.0)
Operatives	−30.7	12.7	−1.1	42.8
	(7.9)	(15.0)	(13.2)	(19.3)
Laborers, except farm	−48.1	−3.8	−36.9	193.9
	(4.0)	(4.9)	(0.7)	(1.3)
Service workers, except private household	−14.4	111.7	49.5	83.7
	(0.8)	(3.0)	(5.9)	(16.8)
Private household workers	−51.0	−41.9	7.3	−44.6
	(0.1)	(0)	(7.0)	(4.3)
Occupation not given	—	—	—	—
	(1.1)	(0)	(5.1)	(0)
All occupations	−45.5	−24.6	−13.7	11.8
	(6,832)	(2,806)	(1,136)	(1,096)
U.S.—all occupations	7.3	10.7	34.7	37.8
	(40,510)	(48,139)	(15,715)	(29,170)

Source: U.S. Dep. Commerce 1953, 1963, 1972.

[a] The numbers in parentheses under 1950–60 (1960–70) column gives the distribution of the male (female) civilian labor force across occupations in 1950 (1970), except for the all occupations categories that give total workers in civilian labor force (thousands).

is lower but is rising similarly to the participation rate of other women. For example, in March 1959 the labor force participation rate of all married women was 31%. For farm wives it was 27%. By March 1971 the percentages had increased to 41% and 37%, respectively (U.S. Dep. Labor).

The Falling Number of Nonwhite Farmers

During the past 25 years, a dramatic fall has occurred in the number of nonwhite farmers, primarily in the South (see table 3).[6] Before the Civil War, many blacks were slaves on southern farms and plantations. Freeing the slaves, which was not accompanied by land reform, upset factor ownership proportions but left largely unchanged the number of blacks working in agriculture. The white landowners had few options for labor aside from former slaves, and the former slaves had few options outside southern agriculture. The sharecropper tenure system became a new and successful institutional arrangement for carrying out voluntary exchange between landowners and workers in the post-Civil War South. The shared incentives by tenants and landowners helped insure cooperation between them, diligence of work by tenants, and willingness of landowners to help tenants acquire cooperating farm inputs (Reid). But not all blacks were sharecroppers or even tenants, and not all sharecroppers were black. In 1920, 76% (36%) of southern nonwhite farm operators were tenants (sharecroppers). By 1950, their percentage had fallen to 65% (table 3).

Both nonwhite tenants and owners in the South have had a history of small farm sizes (Lewis). Most of these small, largely tenant-operated farms have been a casualty of labor-saving technological advances in agricultural production. Major technical ad-

[6] More than 95% of the U.S. nonwhite farm operators are in the South.

Table 3. Changing Distribution of Farms and Number of Farms by Race, South

Race	Distribution of Farms			Percentage Change in Number of Farms	
	1950	1959	1969	1950–59	1959–69
Total, farm operators	2,652,423	1,645,028	1,161,399	−38.0	−29.4
White, total (%)	78.9	83.9	92.2	−34.1	−22.3
Tenants (%)	20.4	13.9	10.2	−57.7	−48.2
Nonwhite, total (%)	21.1	16.1	7.8	−52.5	−66.1
Tenants (%)	13.8	8.4	1.6	−62.2	−86.8

Source: U.S. Dep. Commerce 1952, 1962, 1968, 1973.

vances have been the switch from animal to mechanical power in seedbed preparation (1930s and 1940s), from hand weeding to flame cultivation and herbicides (late 1940s through 1960s), and from hand to mechanical harvesting of cotton and tobacco (1950s and 1970s, respectively). These advances brought a dramatic fall in the demand for unskilled labor in southern agriculture. Landowners with a few hired workers and modern technology have replaced thousands of tenants and other farmers in the South.

Because of the small size of nonwhite farms and larger share of tenant nonwhite than of white farmers, it is not surprising that during the past 25 years nonwhite farmers have quit farming and shifted to the nonfarm population and labor market at a faster rate than have white farmers (table 3).[7] Unfortunately, most rural farm nonwhites have been poorly prepared for nonfarm jobs. They have low education levels and few marketable skills. Those that move to the cities have become a growing welfare burden because they have had generally high unemployment rates and unskilled workers are among the first to be laid off in a business cycle downturn.

Increasing Importance of Nonfarm Income

The welfare of farmers, even large ones, is not determined solely by incomes from their farms. The farm population's share of personal income from nonfarm sources has increased steadily from 27% in 1950 to 50% in the 1970s, except for 1973 when net farm income rose dramatically.[8] Thus, a large and growing income share of the farm population is not from farming. This change has reduced the vulnerability of the farm population to wide swings in farm prices and net farm income.

Another development is the remarkable increase since 1960 of the relative and real incomes of farm families that operate small farms. This change also is tied to rising nonfarm incomes. Because the index of prices received by farmers was approximately unchanged between 1960 and 1965 but about doubled between 1965 and 1975, a constant dollar value definition of "small" farm size is used in the comparison. A farm is small in 1960 and 1965 if it had sales of less than $5,000 but in 1975 if it had sales of less than $10,000.[9] For these small farms, average constant dollar nonfarm income increased from $2,789 in 1960, to $4,652 in 1965 (by 68%), and to $7,862 in 1975 (by 69% over 1965).[10] Average constant dollar realized net farm income remained unchanged between 1960 and 1965, but it actually fell by $337 between 1965 and 1975.

This rising nonfarm income of small farmers has caused a dramatic increase in their family income positions relative to larger farmers. In 1960, average total (farm and nonfarm) income for small farmers was only half as large as for the larger farmers, but by 1975 it had improved to 66%.[11] Rising nonfarm incomes of families that operate small farms have been successful in improving the relative income position of these families even though most government programs have had little positive effect.

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[7] Discrimination against nonwhites in obtaining education and extension information also placed nonwhite farmers at a disadvantage in competing against white farmers (Huffman 1977a).

[8] More than 70% of the income from nonfarm sources is wage and salary income of farm males and females from nonfarm employment. Income from nonfarm sources also includes nonfarm business and professional income, rents from nonfarm real estate, dividends, interest, unemployment compensation, and social security payments.

[9] The number of farms and amount of nonfarm income by sales class are USDA estimates (USDA 1976).

[10] Deflator is the index of prices paid by farmers for family living items, 1967 = 100.

[11] We do not know how many of the small farmers of 1960 were still around in 1975 or, if they were still farming, what size of farm they were operating.

Integration of Farm and Nonfarm Labor Markets

In early days travel was slow, and workers had to live close to their job sites. Improved rural (and urban) roads and cars and reduced time and money costs of transportation have made it possible for people to live a greater distance from their jobs. Decisions on residence are not so closely tied to job-site location. This reduction in commuting costs has enhanced integration of farm and nonfarm labor markets.[12]

During the past 25 years, striking changes have occurred in the integration of farm and nonfarm labor markets. The major changes are an increasing percentage of the farm population in the labor force has nonfarm jobs and an increasing percentage of those who work on farms reside elsewhere. First, the reported occupations of resident farm males and females show some of this change (table 2). In 1950 75% of the farm resident males and 41% of the farm females in the civilian labor force ≥ 14 years of age) reported their occupation as being one of the two farm occupations (farmers and farm managers or farm laborers and farm foremen).[13] In 1970 this frequency had fallen to 49% for farm males and to only 10% for farm females. Thus, the percentage point increase in reported nonfarm occupations was 25 for farm males and 31 for farm females.

Also, the increasing amount of off-farm work by farm family members shows another aspect of taking nonfarm jobs. Nationally, the percentage of farm operators reporting any off-farm work during the census year has risen steadily from 39% in 1950 to 54% in 1969.[14] Operators working 100 days or more per year off their farms increased from 23% to 40% during the same period. Perhaps surprisingly, all regions except for the Northeast showed a similar rise in the off-farm participation rate of farm operators (table 4). However, only in the North Central region did the absolute number of farmers participating in off-farm work actually increase. For farm wives, the nonfarm labor force participation rate increased from 16% in March 1959 to 26% in March 1971 (U.S. Dep. Labor).

[12] During 1948–72 the relative price of gasoline declined. But in 1973 there was an abrupt change in this trend when the price of petroleum products rose rapidly. A rising relative price of gasoline could reverse the trend toward greater integration of farm and nonfarm labor markets.

[13] Occupation is determined by where the individual spent the largest number of hours working during the census week. If he was unemployed, the occupation is the last one where the person was employed.

[14] Most of the off-farm work is at nonfarm jobs and very little is work on other farms for pay. For example, in 1964, 96% of the total off-farm work days of farm operators was spent in nonfarm work (U.S. Dep. Commerce 1968).

Table 4. Farms and Farm Operators Reporting Off-Farm Work, by Census Regions

Regions	1949	1959	1969	Percentage Change[a] 1949–59	1959–69
U.S.					
No. of farms	5,382,162	3,707,973	2,730,250	−31.1	−26.4
No. reporting any off-farm work (%)	38.8	44.9	54.3	−20.4	−10.9
No. reporting ≥ 100 days (%)	23.3	29.9	39.9	−10.7	−1.5
Census regions					
Northeast					
No. of farms	399,927	254,727	151,866	−31.1	−26.4
No. reporting any off-farm work (%)	47.1	47.7	31.0	−35.5	−35.0
No. reporting ≥ 100 days (%)	34.4	35.6	24.2	−34.2	−32.0
North Central					
No. of farms	1,868,139	1,459,765	1,151,884	−21.8	−21.1
No. reporting any off-farm work (%)	34.6	33.6	50.5	−24.1	18.5
No. reporting ≥ 100 days (%)	18.5	24.1	34.4	1.7	12.6
South					
No. of farms	2,652,423	1,645,028	1,161,399	−38.0	−29.4
No. reporting any off-farm work (%)	39.3	47.5	58.2	−25.0	−13.5
No. reporting ≥ 100 days (%)	23.7	32.9	45.0	−14.0	−3.5
West					
No. of farms	461,673	348,453	265,101	−25.4	−24.1
No. reporting any off-farm work (%)	46.2	48.9	55.1	−22.1	−12.2
No. reporting ≥ 100 days (%)	30.7	35.6	41.7	−15.2	−8.2

Source: U.S. Dep. Commerce 1952, 1962, 1968, 1973.
[a] Percentage change in number of farms in each class.

What do we know about farm households' decisions on off-farm work? First, the off-farm jobs pay much higher wage rates than the going wage rate for farm hired labor. For example, in 1964 the national average daily wage rate for off-farm work by farm operators was 2.33 times the average daily wage rate for hired farm labor. For other farm household members, the factor was 1.78.[15] Second, decisions on off-farm work are part of the relatively complex joint farm production and household consumption decisions. Inputs into farm production (and farm output) and inputs of goods and human time into household consumption are determined jointly. Third, results from fitting an off-farm labor supply function to county average per farm data for Iowa, North Carolina, and Oklahoma show that off-farm work by farmers responds positively to their own wage rate but negatively to the wage rate of other household members (Huffman 1977b). Imputed farm output (from an estimated production function) has an expected negative effect. The education of farmers affects the quantity of their off-farm work in three ways. It has a positive effect on farm output and on their wage rate, and each of these variables enters the off-farm labor supply function. Then education has a separate positive direct effect on off-farm work. The net effect of farmers' education on their off-farm labor supply is, however, positive.

Last, an increasing percentage of males and females who do farm work do not reside on farms. The percentage of males reporting occupations of farmers and farm managers and living off farms increased from 8% in 1950 to 20% in 1970. For males reporting occupations of farm laborers and farm foremen and living off farms, the increase for the same period was from 33% to 66% (see footnote 13). A similar change occurred for females who reported these two farm occupations. This integration has been facilitated by reduced transportation and communications costs in rural areas and is partly a consequence of rising labor force participation of married women. During the past 25 years, farm and nonfarm labor markets have become more integrated as an increasing proportion of the farm population that is in the labor force has taken nonfarm jobs and as an increasing percentage of those who work on farms reside elsewhere.

[15] The data on off-farm days worked and wage and salary income of farm households are taken from the 1964 *Census of Agriculture*. The wage data for hired farm labor are from the USDA (1965) publication *Farm Labor*.

Implications

Agricultural policy is currently up for review and revision. The dramatic long-term changes in the interaction between farm and nonfarm labor markets between 1950 and 1970 should be recognized in drafting new legislation. It will be easy to draft legislation that effectively attempts to protect agriculture from needed long-term resource adjustments, especially the reduction of labor in agriculture. To the extent that protection is successful, it only delays the time when resource adjustment must occur.

The increasing interaction between farm and nonfarm labor markets has increased the short-run elasticity of supply of labor in the farm labor market. When this fact is combined with the increasing share of farm output costs that are due to the purchased inputs that are highly elastic in supply, it is clear that small errors in setting farm commodity support prices too high will be very costly to U.S. taxpayers and consumers. Unfortunately, the costliness of such mistakes may become all too obvious in the near future.

The increasing share of farm family income from nonfarm sources and rising off-farm labor force participation rates of farm males and females have made the economic welfare of farm families less dependent on net farm income. These changes make even clearer that target prices for agricultural commodities are an inefficient method of transferring income to low income farm families. A general welfare reform that leads to some type of negative income tax or income maintenance program seems a better income transfer plan. Federal assistance would then be based upon being poor rather than being in some (other) special interest class.

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Interactions Between Farm and Nonfarm Labor Markets: Discussion

Sigurd R. Nilsen

Huffman's paper is an excellent review of some of the primary factors contributing to the decline of the farm population during the past twenty-five years. The historical perspective provides valuable insight into the transfer of labor from the farm to the nonfarm sector. However, in terms of providing a useful perspective on rural labor markets, this approach suffers from problems introduced as a result of dealing with the farm sector in isolation from other economic activities in rural areas. Huffman notes that the farm population has declined from 15% to 5% of total population and that the primary source of support for small farmers in 1975 is from nonfarm income. Yet, he still deals with farm labor as if it were isolated from alternate employment opportunities.

The agricultural sector is an important factor in the economy of many rural areas. However, the recent growth of employment in manufacturing and the reversal in the trend of rural population loss indicates that rural areas are not totally dependent upon agriculture for an economic base. This implies that there may be much more interaction between the farm and nonfarm sectors than Huffman indicates.

According to Rowe and Smith's *Hired Farm Working Force of 1975*, 54% of those who did hired farm work were otherwise not in the labor force in 1975, being mostly students or housewives. This group accounted for over 25% of hired man-days worked in agriculture. This study also found that during 1973–75 an average of 77% of farmworkers were not farm residents. Thus, it appears that investigations of farm labor markets should not be executed in isolation from other sectors of the rural economy. This is further supported by Huffman's discussion of the relative farm and nonfarm wage rates. Huffman's reasoning seems to be somewhat contradictory when he implicitly assumes that agriculture is not only an economically isolated sector but is also physically isolated. If it were, how could small farmers earn an average of eight times their farm income from nonfarm employment?

Huffman's paper has thus provided an excellent starting point from which to reorient investigations of farm labor markets. We must investigate not only the off-farm employment of the farm population but also the farm employment of nonfarm residents and the alternative nonfarm employment opportunities available to rural residents. Huffman implicitly concedes this point when he notes, "The major changes [in the integration of farm and nonfarm labor markets during the past twenty-five years] are an increasing percentage of the farm population in the labor force has nonfarm jobs and an increasing percentage of those who work on farms reside elsewhere." He does not utilize the evidence cited to develop a more integrated conceptualization of rural labor markets where the farm is but one sector. Instead, he reverts back to the farm as the relevant unit of analysis. This perspective is most likely the result partially of his own biases and partially a result of the paucity of data that provide employment information on all sectors of the rural economy. The treatment of the farm as a quasi-business, quasi-household unit further confuses both data collection and analysis.

The conclusion that target prices are an inefficient method of transferring income to low income farm families is well taken. However, based upon his own observations of income from nonfarm sources, an income transfer plan for the rural poor should be only part of a broader based rural development program.

In my view, Huffman's premature conclusion that an alternative income transfer plan is the relevant approach to aiding needy farm families results again from the treatment of the

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Sigurd R. Nilsen is an economist with the Economic Research Service, U.S. Department of Agriculture.

The views expressed here are those of the author and do not necessarily represent the position of the U.S. Department of Agriculture.

farm in isolation. Rural development is not synonymous with farm development. To constructively aid the rural population, we must first understand the structure and processes of rural labor markets. Then we may determine what action, if any, is necessary to promote relevant employment opportunities for rural residents and also what role an income transfer plan should play in the overall scheme.

In conclusion, I would like to make some remarks regarding my own views pertaining to rural labor market analysis. First, I believe I have made my feelings clear that agriculture, and the farm, should be viewed as a sector interrelated with others in the rural economy. Second, particularly with respect to labor supply analysis, we must build upon existing work, which is focused mainly upon urban or urban-biased national studies, to determine how the rural population behaves, what differences exist in the labor supply decisions of rural vis-à-vis urban residents, and how the mass, diversity, and access to employment opportunities affects labor supply in rural areas.

My final point concerns the definition of rural. Researchers and institutions have many conceptions of what is rural. For some it is areas characterized by open country, for others it is all nonmetropolitan counties, still others regard any political unit with a population less than 2,500 as rural. The definition adopted by a particular researcher or institution is of marginal importance, except of course when it affects the distribution of public funds. What is important is that all factors that differentiate one area from another be explicitly included in any analysis of rural labor markets. For example, a resident of a rural portion of a standard metropolitan statistical area will most likely face a different set of employment opportunities and have better access to them than a resident of a small town in a nonmetropolitan county. Thus, characteristics such as industrial and occupation structure and the transportation system of an area are important factors.

My comments on Huffman's paper may be viewed by some as straying far afield from my prescribed task. However, I submit that investigations of the interactions between farm and nonfarm labor markets merit a broader perspective than has heretofore been taken.

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Farm Labor Markets: Discussion

John W. Mamer

These two papers come to the optimistic conclusions that the farm and nonfarm labor markets have become more integrated and are functioning so as to reduce the excess of labor in agriculture. Huffman expresses the hope that public policy will not shield agriculture from "needed long-term resource adjustments, especially the reduction of labor in agriculture."

Martin shares the good news. However, we have to extend his reasoning a little to make explicit the area of agreement. Martin reviews the recent past with respect to labor relations in agriculture. He, like Huffman, finds good news in the evolution of events. We are evolving in agriculture a stable system of labor relations—at least such an outcome is in prospect. This new style of labor relations most fully developed in California, where the enactment of the Agricultural Labor Relations Act of 1975 facilitates the development of unionization and collective bargaining. The initial period has been a little unstable, but Martin concludes "after the resolution of short-term initiation problems, agricultural labor relations promise to achieve a degree of stability at least congruent with the stability of agriculture."

Martin does not argue directly that a reduction of labor inputs in agriculture is an outcome likely to be associated with an expansion of labor relations carried on under a regimen of collective bargaining. But he expects the labor force mobilized to shrink in size as more employment per worker is achieved under collective bargaining. An effective union will tend to reserve employment for those members who have more seniority.

Both authors thus are favorably disposed toward a reduction of labor in agriculture. Although both union rationing of jobs among members and the market mechanism will tend to shift human resources out of agriculture, we should recognize these two systems work in quite different ways. Both are functioning simultaneously in the nonfarm economy currently. Economists could contribute to rational public decision making by discussion and analysis of the efficiency and equity of these two systems for allocating human resources among occupations.

The evidence offered to support the optimistic conclusions warrants some comment. The main bits of evidence are a reduction in per capita disposable income differentials, the increased tendency for those who work on the farm to reside elsewhere, and the increasing proportion of farm operators who do nonfarm work. These bits of evidence may be consistent with the proposition that farm and nonfarm labor markets have become more integrated. But had the wage differentials between farm and nonfarm work, say, between farm and factory work, been examined, the evidence supporting integration would not have been so convincing.

Several conflicting trends may be operative at the same time. The wage rate differential between farm and factory seems to have remained relatively constant over the past two decades, in California and in the nation as a whole. Yet here in California the main exodus of human resources from agriculture has been in the farm operator and family labor category. Average annual employment of hired workers has remained relatively stable.

With regard to the increased number of individuals who do both farm and nonfarm work, it may be that the hired farm labor market and the nonorganized nonfarm labor market are becoming more closely linked. Fuller and Van Vuuren suggest that the linkage is not symmetrical. A relatively larger proportion of those individuals who do both farm and nonfarm work are nonfarm workers who enter the farm labor market as a salvage operation, seeking to obtain such income as they can during those periods when they cannot find nonfarm work. The proportion of farm workers who move into nonfarm work when farm work is not available to them is on a much smaller scale. Fuller and Van Vuuren conclude "the dominant characteristic of the

John W. Mamer is with the Cooperative Extension Service, University of California, Berkeley.

hired farm labor market is clear. It is an open, ready-access market for salvage of zero and low opportunity cost time, and its earnings record reflects this dominant characteristic" (p. 154).

If the farm labor market is a salvage labor market in which farm workers face increased competition from nonfarm workers when nonfarm employment is cyclically or seasonally low, the farm worker may be absorbing a disproportionate share of the burden of economic adjustment. No doubt farm labor unions will want to regulate this inflow into agriculture of nonfarm workers.

Martin suggests that unions will also be interested in the flow of new technology into agriculture. He suggests that, unless unions are able to negotiate contracts that provide directly for labor a share of the benefits of new labor-saving technology, labor relations in agriculture will face another element of uncertainty.

This is a very difficult problem area. What is an optimum means of distributing the benefits of technological advance? United Farm Workers lobbyists operating in the California State Legislature have taken an antagonistic stand toward publicly supported mechanization research, focusing their attention on the fact that jobs are destroyed. Little or no attention is paid to the possibility of lower food costs, more stable annual employment, or the possibility of higher wages.

We have moved some distance from the President's Commission on Migratory Labor of the early 1950s. In its report, *Migratory Labor in American Agriculture*, the Commission suggested that the "mechanization of hand tasks may restore greater balance to the seasonal distribution of farm employment" (p. 16). In those days nearly everyone was confident that those workers displaced by machines would be quickly shifted to new and better jobs.

It is quite easy for academic economists to note that the fruits of technological advance in agriculture are passed along to the consumers (including farm workers) and that in the long run few or none of the benefits are retained by the farm employer operating under something approaching atomistic competition. But the reality faced by the farm worker is that the economy has not been expanding fast enough to enable the displaced farm worker to find a new and better job in anything like a reasonable amount of time, if at all, given his experience and skills.

The farm worker sees that as the mechanical tomato harvester came into use, the acreage and production of tomatoes increased so much that possibly total employment associated with tomato production, processing, transporting, and marketing may be higher now than it was before the tomato harvester came into use. But the farm worker does not perceive that he shared equitably in the benefits of the progress called the mechanization of tomato harvest. His perception of his welfare would no doubt be different if he had been facing a situation of expanding employment opportunities.

In drawing attention to these problems and issues, I do not want to imply that the farm and nonfarm labor markets are not becoming integrated. I would argue that here in California the laws and regulations pertaining to the employment of hired labor as well as the nature of farm jobs themselves have tended to, if not integrate farm and nonfarm labor markets, cause them to develop along parallel lines. The optimism that characterized these papers may be appropriate if we recognize that thorny issues and difficult problems remain to be resolved.

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Energy: Policy and Research Issues
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Agriculture and Energy Use in the Year 2000

Otto C. Doering III

As an exercise in crystal ball gazing, I can do little to improve upon the unenviable record of agricultural economists over the last few years. In fact, I am thoroughly convinced that I cannot predict the character of agriculture or the food system in the year 2000. However, some of the relationships that will determine the character of the system can be identified, and some important questions can be asked about the forces that will shape the system.

The sprint to the year 2000 is a relatively short time span, already shorter than the post-World War II era. My assumptions about this era are as follows. First, I do not see any more technological change taking place between 1977 and 2000 than occurred from 1945 to 1977. This assumption purposely negates any notions that technology will solve our problems. Futurists would claim that this does not allow for enough new technology, but remember that immense changes did occur in the agricultural sector in the 1950s and 1960s. In addition, new technology that substituted other resources for energy would be reversing a long trend.

In terms of energy resources, I assume that the economy will still be dependent upon the same fossil fuels in use today. Based on the projections of the Workshop on Alternative Energy Strategies (Wilson), oil production will peak around 1990, while natural gas production has already done so. The consumption of oil may be as high or higher than it is today, but the consumption of natural gas is projected to be 15% lower in the year 2000. Fuel prices will increase but not by as much as many imagine. The price of oil is projected at over $17 a barrel in 1977 dollars. The price of other fuels will be equivalent to this on a heat-unit basis, which is critical for the natural gas projections.

Most basic energy applications on the farm and in the food system will be much the same in the year 2000 as they are today. This stems from the particular nature of energy applications in the food system and from the fact that there are often good reasons why resources are being combined and utilized as they are today. In 1974, roughly 22% of the energy used in the United States was for the food, fiber, and forest product sector. Of this, some 16.5% was for the production, processing, marketing, and consumption of food and kindred products (table 1).

It is more helpful to look at the energy use by fuel type in the different sectors and then consider the purpose of use in each case. Utilization by fuel type is given in table 2. Most of the gasoline and diesel fuel used in production is for motive power. Fuel oil is used in processing and marketing largely for heat, while transportation requires gasoline and diesel fuel.

Most gas fuels are used on an indirect basis in production for petrochemicals, primarily nitrogen fertilizer. The direct use given here is for grain drying, flue-curing tobacco, and space heating. The gas used in processing is for heat applications, while most used in marketing is for space heating or cooling. In home preparation it is used for cooking and away from home for cooking, space heating, and cooling.

Most of the electricity used in agricultural production is for motor power and the remainder is for heating and cooling applications. That used in processing is for both heating and

Otto C. Doering III is an associate professor in the Department of Agricultural Economics, Purdue University.

Table 1. Direct and Indirect Energy Use in the Food System, 1974

Activity	Percentage of Total U.S. Use
Production	2.9
Processing	4.8
Marketing	1.3
Consumption level preservation and preparation	
In home	4.3
Away from home	2.8
Transportation across the system	2.5[a]
	16.5

Source: Federal Energy Administration.
[a] Some of this amount is included in the earlier activities, so the column will sum to more than 16.5.

cooling applications. Large amounts are used in marketing to keep foods refrigerated or frozen. The electricity used in the preparation and consumption of food is for cooking, refrigeration, and space heating or cooling. Finally, the coal is used for heat in food processing.

While this gives an indication of the specific uses by fuel type within segments of the food sector today, there are reasons for the application of energy to the food system in each case that provide us with a better basis for judging future use in conjunction with the specific knowledge about current use. Energy has been applied to agriculture in increasing amounts for the following general reasons: to replace human and animal labor, to increase production, to lessen risk, and to enhance or change product form or quality.

Given a specific reason for the application of energy in a segment of the food system, what would cause substantial change in this use between now and the year 2000? One such cause would be a change in the relative price of energy, energy-substituting inputs, and final products. Strangely enough, the new cadre of energy economists has tended to ignore the relative price issue, yet it is relative prices that drive or negate resource substitution. We hear that doubled gasoline prices have not reduced consumption, without being told that the price of gasoline, relative to other goods, has increased much less. In a number of cases, relative energy prices in the food system have remained much the same as in the 1960s. The operative question is: how much different will things be in 2000, in the aggregate and by regions?

Another cause of substantial change in energy use in the food system would be shortages of energy in the form, time, and place it is needed. The threat of a fuel shortage, given the attendant risk of spoilage that pervades the food system, might well induce fuel switching, conservation, storage, or changes in technology when relative prices would not.

How do these two factors relate to the basic reasons for applying energy to the food system as we do today? Energy has been substituted for human and animal labor throughout the food system not only because of the direct comparative costs but also because of the increased scale of operation possible for a given management input. Current midwestern crop budgets allow $7 to $10 for all fuels and oils, including drying fuel, per acre of corn. At the same time land charges are $70 to $100 an acre. Given the sunk cost in machinery, the

Table 2. Current Direct Food Sector Use of Different Fuels

	Gasoline and Diesel	Liquefied Petroleum and Natural Gas	Electricity	Coal
	Trillion BTU			
Production	945	290	391	1
Processing	130	485	459	80
Marketing	130	145	1,360	—
Home preparation and consumption	—	175	2,550	—
Away from home preparation and consumption	2,150	2,150	2,150	2,150
Transportation	1,175	—	—	—

Source: Doering et al.

variable energy cost for motive power has been relatively minor in comparison to the cost of land and other inputs, especially with the advantages in systems, materials handling, and management scale that have been gained.

Fuel scarcities are more likely to be the major motivating force for moving away from the direct use of fossil fuels for motive power. However, in the short- and intermediate-term this might well lead to investment in storage facilities rather than to the substitution of human or draft labor for fossil fuels. While the use of fossil fuels for motive power should continue to the year 2000, systems and equipment will be modified to improve energy efficiency in response to relative price increases or availability problems for fossil fuels.

Fossil fuels will likely continue to be used to lessen risk in production, processing, marketing, and home preservation. In each segment of the food system, decision makers consider only their own energy cost against the total value of the product. Within each segment the value of the total energy input is a relatively small proportion of the value of the product, as is illustrated in table 3.

New systems that use less energy or renewable energy but result in increased risk have a severe hurdle to overcome for adoption. We may see intermediate-term changes in the type of energy that is used for this purpose. Natural gas is widely used in food preservation and processing. The equalization of the price of natural gas with that of other fuels as well as problems of availability will encourage a shift to other fuels. For example, crop drying should remain economic as a practice in comparison with field dry down and/or shorter season varieties (Peart and Doering). However, the gasification of corn cobs at the farm to provide a low Btu (British thermal unit) gas for drying can be economically feasible with a doubling of liquefied petroleum gas prices (O'Hare). The basic preservation and risk-averting systems will stay much the same while switching between fossil fuels and the introduction of some renewable fuels occurs to allow tested practices to continue.

More change should occur in the energy used to increase production, but this would depend on changes in the relative price of production enhancing energy inputs as compared with substitute resources and final product prices. Thirty-one percent of the energy used in agricultural production is in the form of nitrogen fertilizer and 13% is for irrigation fuel. Changes in production energy use are likely to be greatest in these two areas of indirect and direct use.

The price and availability of natural gas will be the critical factor. A current average crude oil price of $1.50 per million Btu's would more than double to $3.13 per million Btu's for oil at $17.50 a barrel in the year 2000. An equalized wellhead price for natural gas would be slightly over $3.00 per 1,000 cubic feet. This should not shock those intrastate markets that are currently at $2.00 or more per 1,000 cubic feet. However, half the intrastate market in Louisiana is contracted at 25¢ or lower. Assuming natural gas at 50¢ per 1,000 cubic feet, only $19.00 would be spent directly on gas in the manufacture of a ton of anhydrous ammonia. This would increase to $114.00 with gas at $3.00. Given anhydrous at $180.00 a ton in the Corn Belt, there is a potential cost increase of $95.00 to a price of $275.00 if this cost were passed through directly. However, the price of fertilizer has tended to be market determined rather than cost determined. Farmers paid over $400.00 a ton for marginal increments of anhydrous a few years ago for use on $3.00 corn. While there are conflicting views (Klepper et al.), large amounts of chemical nitrogen should continue to be used unless the relative price of commodities and land declined substantially between now and the year 2000 (Doering).

Pump irrigation fueled by natural gas faces a proportionally more severe increase in costs.

Table 3. Value of the Direct Energy Input Compared with the Value of Product

Stage of Use	Value of Product	Value of Energy Input	Energy Input as Percentage of Product
	----- Billion Dollars -----		
Production	90.8	4.5	5
Processing	151.7	1.4	1
Marketing	144	4.7	3
Home preparation	145.3	10.3	7
Away from home	67	8.1	12

Where current gas costs might be 50¢ or less per 1,000 cubic feet, the six-fold increase to $3.00 appears unsustainable in the light of current crop values and declining water tables (Skold). We can certainly expect to see a change in the amount of water used and in the extent and location of irrigated agriculture.

The greatest prospect for change exists for the energy used to enhance or change product form or quality. In the past, much of the energy that has been used for this purpose has been based on consumer preference. Given the wide range of energy requirements for different foods or different versions of the same food (Whittlesey and Lee), there is potential for great flexibility in energy use while still maintaining basic nutritional requirements. As an example, beef production can vary in the intensity of its fossil fuel energy requirement from 1.9 Btu's of energy input per Btu of food value of retail beef to 13.4 Btu's of input per Btu of food output (Ward). The change in product form takes place at various points in the food system, and sometimes extra energy expended at one locale may be saved at another. Thus, any analysis must be on a total food system basis.

So far, this view of the food system in the year 2000 may not have been sufficiently alarmist to be the product of a true believer in the energy dilemma. However, changes in the food system over the next two decades can still be modest even in the face of important changes in resource availability. It is worth reviewing some of the forces that will have impact on the whole economic system as well as the food system.

First, the physical geology of the energy dilemma is real. There is only a fixed amount of fossil fuel resources in the earth's crust. The fact that we may be able to keep going for another twenty-five years at current consumption level, with a mere doubling of real oil prices and a tripling or more of real gas prices, only indicates that more severe adjustments will be necessary after the year 2000.

Second, the United States is becoming increasingly vulnerable to the interruption of its petroleum supplies. During the Arab oil embargo we were importing a bit more than a third of our oil; we are now importing more than half.

Third, we are in a world of growing populations. The energy projections utilized here have the United States consuming about the same amount of oil and less natural gas in the year 2000. This implies that per capita consumption will decline.

Finally, given the very real equity and windfall profit issues, the urge to bypass the price mechanism will make government allocation and price regulation the crucial factor in the adjustments to scarce fossil fuel resources that will take place over the next twenty-five years. The potential for contradictory and counterproductive activities is tremendous. Using agricultural production as an example, Secretary of Agriculture Bergland has urged the agricultural research and extension establishment to devote its efforts towards perfecting and disseminating more energy efficient agricultural systems. At the same time, many officials appear to want to exempt agriculture from the energy price increases that could be expected under the president's energy plan in order to hold down food prices. This is completely contradictory! If agriculture is guaranteed the energy it needs at current prices, there is little incentive for technological development or adoption. In addition, if the agricultural sector is effectively shielded from energy price increases and shortages, it will be a technological dinosaur by the time the rest of the economy finally insists that it rejoins the real world.

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Agriculture and Energy Use in the Year 2000: Discussion of Technological Changes

R. Thomas VanArsdall

Energy-saving technologies that currently are undergoing adoption normally are successful for nonenergy reasons. New technologies still are using energy to increase production, replace labor and other inputs, and reduce risk. Similar motivational forces likely will continue to underlie technological and structural changes for some time.

Over the next two decades, the food system will continue to rely almost entirely upon the U.S. and world community for energy, with very little evidence of decentralized energy production. Relative energy price increases will impact more adversely upon the small farmer. Regional specialization in commodity production is likely to continue. Diesel tractors will not be replaced by human and animal power. Natural gas price increases translated into increased fertilizer costs would result in more efficient fertilizer products and wider use of soil testing. Adjustments will mean more efficient use of both direct and indirect energy inputs to farm production.

Water problems for western irrigators should lead to increased use of moisture-sensing blocks and scheduling, with significant energy savings a byproduct. A sleeper could be intermittent irrigation in the humid East, as experiment station tests in Missouri and Georgia have shown that water applied during periods of plant stress could double yields. Shifts by food processors from oil and gas to coal may be accompanied by more off-peak electrical power use and cogeneration by large users. Improved efficiencies in commercial and home refrigeration will be realized as worn equipment is replaced. Consumer food choices will be similar to those of the present, with more extensive processing and packaging and with more meals eaten away from home.

Given the time, the "hard" sciences will develop the hardware necessary to cope with more serious energy problems. Our mission includes assessing the economic viability of options and dealing with catalysts and inhibitors to desirable change. Major catalysts include government actions such as selective penalties, regulations, and subsidies of both risk and cost; amount and emphasis of funding of research, development, and demonstration (RD&D) programs; sharply changing relative prices with the potential for stimulating substantial fuel shifts and economies; farmers' desire to reduce risks and costs; a competitive drive in other agribusiness to maintain or increase market shares; and real or artificial shortages.

Most inhibitors to change may be categorized in one of the following: unfavorable economics; risk and uncertainty associated with new and unproven practices; inertia, particularly in the form of sunk investment; capital availability and outlay; institutional restrictions in both the public (Environmental Protection Agency, Federal Energy Administration) and private sectors (labor unions); perception—energy users will not act to solve an energy problem unless they believe it exists; and resistance to structural change wrought by technological development, often a more serious obstacle than economics.

A true "worst case" energy scenario, involving severe chronic shortages of oil and gas and high energy prices, appears to be inevitable some time beyond 2000. If an energy shortage is induced artificially through embargo in the near term, the only alternative is government policy ensuring agriculture the energy needed in an allocation framework. The market mechanism alone as an allocator of resources is not enough to cope with the long-run energy problem.

Time is the overriding factor. On the average it takes fifteen years' incubation for a technology to move from the drawing board to widespread adoption, and for energy-related technologies it can be much longer. With

R. Thomas VanArsdall is with the National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture.

major breakthroughs rare, do not hope for "instant" solutions. Most new developments occur in small increments, requiring large investments in RD&D, often with no returns realized for several years. The economics of alternative energy technologies, many as primitive as the first computer, remain unfavorable, expanding the time elapsed before adoption if no subsidy occurs.

Energy prices do not reflect the true present value of energy, impending energy shortages, and a heavy dependence on uncertain foreign supplies. Given that energy is woven deeply within our socioeconomic fiber, the complexity of energy technologies, the overwhelming capital outlay involved, and the tremendous lead times, energy price changes likely will not signal impending problems early enough to permit solutions before the crisis is upon us. RD&D and incentive programs are vital now so that by the time economics justifies change we will be far enough along to avoid disastrous upheavals and dislocations.

Let me leave you with one thought. Development of biomass energy plantations to supply the general economy with energy is a "doomsday" alternative at present. However, one may reflect on the implications of a breakthrough in improved photosynthetic efficiencies upon today's agricultural system.

Agriculture and Energy Use in the Year 2000: Discussion from a Natural Resource Perspective

Joseph R. Barse

Doering is probably right that even major energy changes will not restructure the food system by 2000. Yet sudden energy shocks would be disruptive. Some kinds of new energy development might insure against economic disruption, but at what cost to our land, water, air, and climate?

The Doering et al. data show that our food sector, from farm to city kitchen, depends more heavily upon electricity than the economy as a whole. Electricity accounts for one-third of total energy used in the food sector, whereas it constitutes only 12% of all energy used in the economy. Moreover, electricity used in the food sector is about one-third of the nation's entire electricity consumption. Therefore, I concentrate on the natural resource impacts of electricity development.

There are numerous projections of electricity supply and demand to the year 2000. Teknekron postulates various growth rates in electricity demand and various mixtures of coal-fired and nuclear power. Electricity demand in 2000 ranges from almost quadruple to a bit more than double the demand of 1975. Associated coal output ranges from more than triple to almost double the 600 million tons of 1975.

To achieve such levels of coal production, I estimate that between 1.8 and 2.5 million acres would be disturbed (cumulative) by surface mining by 2000, with an additional 1.5 to 2 million acres taken permanently by the more than 800 new coal and nuclear power plants and facilities. Thus, from 3 to 5 million acres would be directly affected, although much of the mined land would ultimately be reclaimed for productive use. Undoubtedly, some land could not be reclaimed at all, but some would certainly become more productive than before. This assumes enforcement of reclamation laws. However, the distribution of land disturbance could differ greatly under various scenarios, with more disturbance in the West the faster coal output expands and the higher it goes. Given energy policy and development scenarios, geographic impact patterns of land disturbance within our 1.7 billion acres of crop, forest, pasture, and range lands can be estimated by locational impact modeling such as that now underway in the Natural Resource Economics Division, Economic Research Service (Barse, Bender, and Schaub). Then alternative effects in specific areas on land, other resources, or employment can be analyzed.

Degradation of water quality and the disturbance of underground hydrology from both surface and deep mining seem to be especially intractable problems. Some aquifers may be destroyed by mining, others polluted by acid mine drainage, usually beginning through the groundwater. About 6,000 tons of sulfuric acid from mine drainage are produced daily, eventually affecting 13,000 miles of streams. Wells in strip-mined areas are frequently impaired, even after surface reclamation. The area of disturbed hydrology and degraded water quality tends to be much larger than the area disturbed by surface mining. No effective methods have yet been developed to abate these problems on a large scale.

In the West, there is probably enough water in total to accommodate both energy and agriculture. However, in some river basins additional mining and electricity production could compete seriously for surface water with both aquatic needs and irrigated farming. Again, locational impact modeling under alternative scenarios will help to analyze competition for water.

By contrast, air quality impacts may be thought of in the aggregate, since air circulates

Joseph R. Barse is with the Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture.

widely. Long-range atmospheric transport and deposition of pollutants from coal-fired electric plants are now well-established phenomena. Also well documented is the transformation of sulfur dioxide emissions into sulfate aerosols, which can then make rainfall acidic. Stack gas emissions from the Midwest today may join with other emissions as the air moves eastward, becoming concentrated, and may fall to earth in rains anywhere in the East after a few days, depending on weather patterns. There is serious scientific concern about the cumulative effects of frequent acidic precipitation on crop yields, woodlands, and inland lakes throughout the entire Northeast. The Southeast could feel this problem as well, as the Gulf Coast converts to coal-fired electric plants.

Emissions controls and new ways of burning coal could mitigate coal-caused degradation of air quality. In essence, effective mitigation is a three-way race among growth rates for total coal burned, number of emission sources controlled, and control effectiveness. As a society, we still have major choices to make about coal combustion.

According to one Teknekron scenario, annual emissions of sulfur dioxide could be lowered from the current 30 billion pounds to about 15 or 20 billion pounds even with heavy electrification based on coal and stay at about that level to 2000 provided that emissions controls far more strict than we now have can be made to work and are fully deployed. Yet, under a contrasting scenario (same electricity output, but current controls, progressively deployed), roughly 40 billion pounds of sulfur dioxide would be emitted by 2000, well below a level without controls but still a major increase in pollution. Thus, the struggle ahead for better air quality is likely to be extremely difficult, the more difficult the larger the role that coal plays.

Consider also the warnings of some scientists that the accumulation in the atmosphere of carbon dioxide from combustion of coal and other fossil fuels could raise the earth's average temperature and affect the climate. Should coal, then, be deemphasized and nuclear power stressed? Are there other scenarios that more sharply restrain growth in electricity supply and demand? By the year 2000, to what extent could "soft technologies" produce electricity and other energy from renewable sources?

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Agricultural Energy Modeling for Policy Purposes

Earl O. Heady and Dan D. Dvoskin

Major economic problems of rural areas over the last three decades stemmed importantly from the large supply and low real price for energy and energy-related inputs. These problems were not analyzed and modeled as specific energy problems because the energy component was a small part of a broader economic and social system. It was impossible to isolate and quantitatively identify the impact of energy supplies and prices per se. It also is likely that high energy prices in the future will have economic impacts that are so broad that quantification of energy effects will be difficult.

There are, however, energy problems that can be modeled to supply important policy information. Those of the individual farm are rather obvious. The level of energy prices to cause pump irrigation to be unprofitable or grain drying from crop residues to be profitable can be analyzed readily with programming, simulation, or budgeting models. Hence, we turn to broader problem sets. Major future problems will relate especially to energy prices. Prices will be high because supply is short relative to demand or because institutional measures are used to encourage energy conservation, production, or substitution.

Price-Related Problems

Energy price uncertainty is a problem encountered by all types of modeling approaches. Between 1965 and 1972, the farm index of energy and fuel prices rose at the average rate of 1.5% per year (USDA). Over the period 1972–76, it rose at an annual average rate of 15%. Conventionally, we expect econometric models to be built to predict the structure of supply and demand for a resource and thus to forecast prices. But we doubt that data exist for doing so in face of changes in the energy market, which has broken from its past structure. While econometric models may not provide price forecasts, potentials for analysis under uncertain prices exist. Price uncertainty itself presents interesting modeling opportunities. For farms, various decision models under uncertainty might apply. Programming models with parameterized energy prices might be used to evaluate prospects in pump irrigation, substitute energy sources, etc. For more macro aspects of agriculture, different pricing environments provide alternative scenarios in evaluating impacts of varied prices for energy. Contrasting results from these scenarios can be communicated to administrators faced with decisions on energy price, conservation, production, and distribution policies. Alternative price scenarios seem particularly relevant for simulation and programming models developed to trace the impacts of changing energy prices through the agricultural systems.

With major impacts through energy prices, the supply prices of agricultural commodities might be expected to increase and bring forth a second problem set. With the supply function shifting to the left, gross revenue of agriculture should increase under inelastic food demands. If revenue effects override cost effects, net income of agriculture also would increase at sufficiently high energy prices. While these results of new energy price structures theoretically would prevail, we know nothing of the price levels needed to bring them about. Neither do we know the time lag that might cause output to decline under sustained high energy prices. Higher food prices augment problems of inflation, low income families, and export earnings. Tracing quantitatively the impact of high energy prices on food supplies and prices would have considerable potential utility for policy makers. Because

Earl O. Heady is distinguished professor and director of the Center for Agricultural and Rural Development, and Dan Dvoskin is staff economist, Center for Agricultural and Rural Development, Iowa State University.

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few time-series observations under the new energy environment exist, econometrically based models probably cannot predict the effect of higher energy prices on food supplies and prices. Alternatively, simulation and programming models might serve as imperfect substitutes in evaluating certain price impacts. For example, the commodity shadow prices generated under various energy price levels in a national programming model could suggest how supply prices of commodities may be affected. The normative nature of the estimates would, of course, need to be recognized. No model can answer policy questions of whether energy in agriculture should be subsidized to prevent negative impacts on inflation and low income consumers, but results of the model could suggest indirectly how serious these impacts might be.

As a third major problem set, higher energy prices will spawn inequitable income redistributions. While restrained commodity supply functions for agriculture could increase the sector's aggregate revenue, producers of some commodities and locations will gain at the expense of others. Shifts in income generally will parallel interregional redistributions in crop production and land and water use. Regions with chemicals or groundwater irrigation as dominant inputs can suffer large declines in net income. The decline in resource values can be drastic in areas where irrigation ceases. Linear programming models provide a capability for identifying these interregional shifts. Through shadow price analysis, they also may suggest magnitudes of compensation relevant for sacrificing farm groups. However, income equity problems extend beyond agriculture. Rural communities with an economic base linked to irrigation also may have a sharp decline in income and employment. Input-output models might capture some of the resulting impacts on other rural community sectors as the structure of agriculture shifts due to high energy prices.

The fourth major problem set relating to higher petroleum prices is that of substitution. With price increases for one energy form, other forms will be substituted for it under favorable substitution rates and relative prices. Policy increasingly will be directed at substitution of other energy sources for petroleum. Attention already is being directed to solar grain drying, solar-powered irrigation, anaerobic digestion of manure, harvesting agriculture's biomass for conversion to electricity, and production of energy crops. The feasibility of some of these conversions can best be tested by farm-level models. Harvesting and transporting biomass to a generating plant implies a model with spatial and allocative features such as linear programming. On a larger scale where biomass harvesting and energy plant production compete with food production in a national context, both simulation and programming could be model candidates. A nod seems to go to programming in its ability to incorporate more detail by location and to allocate resources and regions to energy or food crops relative to energy processing centers. Such models can provide information, although not on a predictive basis as in a statistical model, on levels of petroleum and coal prices necessary to cause either source of substitution to be economic, the number and location of generating plants needed, the land and crops best allocated to energy production, and similar items. Coupled with an input-output component, they could indicate requirements and impacts on other sectors of agricultural communities.

Opportunities and Limitations in Modeling

We designated four broad problem areas related to higher energy prices, namely, price uncertainty, higher supply prices for agricultural commodities and food, changes in income and its distribution, and the substitution of energy forms. Most specific energy problems fall in these categories. These problem sets vary so much in nature that a single overall model cannot be specified to provide a quantitative base for policy decisions in all of them. Aside from firm models, some of them will need to be on the scale of a small region, e.g., the supply area of a generating plant. In other cases, they will need to be on the scale of a large region, e.g., an entire region of groundwater irrigation. Some problems require a national model with interregional linkages to indicate pricing and income distribution effects.

Four categories of models are candidates for evaluating impacts under rising energy prices or energy shortages and include econometric models for estimating behavioral responses with respect to changing energy prices, simulation models to trace impacts through a system with synthesized or statistical estimates of parameters, input-output models to describe

interrelationships between energy and other subsectors under specified changes in demands, and mathematical programming that provides a normative approach in describing potential response, alternative allocations, resource values, and related quantities. Each approach has advantages and disadvantages relative to different problems to be analyzed.

Potentials for statistical models are limited because of restricted time-series observations in an economic environment where energy prices are high. They are even more limited for analysis of problems such as biomass utilization or energy crop production in agriculture. Similarly, input-output models can describe interrelationships in use of energy and other inputs or outputs but are restricted importantly by the amount of data available or a complete lack of historic data relating to nonconventional energy forms or utilization methods. Simulation models are more flexible in the sense that parameter estimates can be synthesized for new alternatives. Yet building up data sets can be burdensome for this method and for programming models. Programming has the potential of providing great detail of energy pricing or supply impacts on land and water use or the environment, resource values, interregional redistributions in production, farm income, and related quantities. Yet the results are generated in a normative framework and thus are somewhat qualitative characterizations of behavior expected under future "real world" conditions.

Data for programming and simulation models also are scarce. However, opportunity to generate coefficients for them does exist in engineering approaches. The estimates can be improved over time through engaging physical scientists in the process and in more detailed specifications of the models and their parameters. Initiation of federal projects for specific purposes of estimating basic quantities can help. An example is the project to provide county estimates of biomass availability from crop residues (Alich, Inman, and Ernest). Data will be improved as more people work on the problem set for a longer time period. Cooperation among different groups working on energy models can be helpful.

Validation problems exist both for estimates of parameters to be used in models and for the models themselves. Difficulty in validation of parameter estimates prevail especially where the coefficients must be generated by engineering processes. Perhaps validation is best approximated in breaking a process into its components and estimating the energy quantities separately. Checking parameter estimates with scientists experienced in particular fields could be useful. After an initial set of coefficients has been estimated, a Delphi survey could be conducted among scientists experienced in the area. Problems of model validation prevail especially for simulations or analyses of situations that have not previously prevailed. As a substitute, validation is best accomplished through use of careful logic in specifying the model, a detailed a priori representation of the system being modeled, and careful gauging of empirical results against general knowledge of the real world.

Modeling efforts will be improved as we have more experience. One seldom develops the all-time model on first effort. Instead, several generations of models must be built. While early generation models may be incomplete, they can provide information that allows more efficient policies than if decisions were made "in the dark." They improve as subsequent generations are more completely specified, include greater detail, and use improved data and as more persons work on energy problems.

A National Programming Model

Our research has been by means of a national programming model (Dvoskin and Heady; Dvoskin, Heady and English). It is specified for the analysis of the relationships of energy prices and supplies with land use, water use and supply sources, fertilizer use, tillage practices, commodity supply prices, and interregional shifts in resource use, production, resource values, and farm income. This model allows analysis of problems of importance to the whole of agriculture and its regions.

The current model has land restraints for 105 producing regions, 938 restraints overall, and 12,000 real activities. It provides regional detail on land and water use, crops grown, tillage practices, energy and fertilizer use, and shadow prices for resources and commodities. Activities in the model simulate crop rotations, water transfer and distribution, commodity transportation, chemical nitrogen supplies, manure nitrogen supplies, and energy supplies. Point commodity demands and a transportation submodel are defined for the model's 28 market regions. The model allows

replacement of nitrogen fertilizers by animal wastes and nitrogen fixation. It allows interregional shifts in crop mixes, substitution among minimum and conventional tillage practices, and different levels of nitrogen and water use on crops as energy prices vary.

Major scenarios analyzed include higher prices and reduced supplies of energy. One modification minimized national energy use in crop production (Dvoskin and Heady). Another examined policies of natural gas deregulation and curtailment for irrigation (Dvoskin, Heady, and English). A new version of the model evaluates potentials in harvesting crop residues and producing energy crops. Model solutions suggest important adjustments and regional redistributions under various energy situations. High energy prices cause important interregional shifts in resource use, crop production, and income. Impacts are greatest in the energy-intensive irrigated regions. The model identifies the regions shifting to dryland agriculture. It also shows dryland regions that would gain in producing crops formerly grown in irrigated areas. It indicates the extent by which land might be substituted for energy through interregional land use shifts. Future solutions may show whether this type of adjustment is more efficient than harvesting biomass, producing energy crops, or other energy adjustments. Since it generates shadow prices for land, water, and commodities in each region, the model provides normative indication within agriculture of the distribution of income sacrifices and benefits as energy prices and supplies are varied.

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Agricultural Energy Modeling: Discussion of Input-Output Analysis

Hal W. Everett II

Heady and Dvoskin have done well in defining the quantitative problems related to higher energy prices. In addition, their discussion of the modeling approaches that can be taken towards analyzing these problems was quite comprehensive. Since little fault can be found with their paper, I turn to the primary task assigned to me: to elaborate on the merits and demerits of using the input-output approach in agricultural energy modeling.

Energy price changes affect the economy directly through substitution and income effects occurring in individual sectors and indirectly through the intersectoral effects that result from the changed input requirements, production levels, and prices of each of these sectors. The importance and primary advantage of input-output modeling is that it captures the interrelationships between the sectors of an economy, enabling one to determine the extent of these direct and indirect effects.

The information obtained from this modeling approach depends on the form of the input-output (I-O) model itself. The I-O model may be solved in its traditional framework of matrix inversion, or it can be solved in a linear programming (LP) or quadratic programming (QP) framework. In its traditional framework, the I-O model can be used to demonstrate the interdependence of an economy and to determine a set of multipliers that reflect the indirect impact on individual sectors of exogenous changes in the final demand of another sector. Both the technical coefficient and the multiplier can be used to examine the potential for income redistribution changes due to energy market changes, as suggested by Heady and Dvoskin.

When placed in a linear programming framework, the I-O model is given several additional positive characteristics. First, such a formulation enables the user to place constraints on the physical availability of a product in the model economy. With this constraint placed on the availability of petroleum, for example, one could determine the degree to which each sector's output may be affected by such a restriction. The LP formation also enables the user to model several sectors with alternative production processes, resulting in the potential to examine the use of substitute energy sources. Finally, the shadow prices that are determined in this formulation represent not only the multipliers of the traditional I-O model but also the added output that could be produced by obtaining an additional unit of a constrained input.

Still other benefits can be gained from an I-O model by placing it in a quadratic programming framework. In this formulation, linear supply and demand functions of factors and outputs are placed in the objective function of the model such that the result represents a price-quantity equilibrium in the economy. Thus, the demand for an input and production in this model responds to price elasticities corresponding to the demand and supply functions of each commodity. Substitution due to price changes may also be examined if cross-elasticity data are available. Yet another benefit of this formulation is the ability to determine real and inflationary impacts, making the problem set of price inflation approachable by input-output models.

Though input-output models appear to be applicable to several of the problem sets suggested by Heady and Dvoskin, they are not without their limitations. In the traditional and LP input-output models, there are the usual restrictive assumptions of horizontal supply and vertical demand functions, the absence of economies of scale, and relative prices being held constant. The I-O models are also quite macro in scale, with only the LP formulation affording disaggregation below the individual sector level. The major limitation of using I-O models, which overshadows those mentioned above, is the data. The Department of Com-

Hal W. Everett II is an agricultural economist with Data Resources, Lexington, Massachusetts.

merce data that form the national I-O tables are five to seven years old when released. One should be greatly concerned about the possibility of some structural change occurring in the economy between the data collection and release dates. This is especially true of the most recent I-O data, which were collected in 1967 and updated in 1970. In the years between now and then, the possibility of significant structural change occurring has greatly increased as a result of the ongoing changes in the domestic and world energy markets. Additional data problems occur in the LP and QP formulations. The LP formulation requires data that represent the physical distribution of energy to each sector by source. The QP formulation requires estimates of the price elasticities of supply and demand for each individual factor and product sector included in the model. While much of this information may be available through secondary sources, it is subject to an age limitation as well as other problems of estimation.

In summary, input-output models are applicable on a very macro level to the problems of determining inflationary, income redistribution, and substitution effects that result from energy market changes. They are recommended, however, only when intersectoral relationships need to be considered and when the limitations of the data are acceptable.

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Agricultural Energy Modeling: Discussion of Linear Programming Models

Vernon R. Eidman

Many economic impacts are of interest in analyzing an energy scenario. It would be useful to have a set of models to estimate the effect of an energy scenario on the prices farmers pay for purchased inputs; the impact at the farm firm level on the product mix, systems of production, and income level by size of firm; the regional distribution of production; regional employment and income levels; the supply-demand balance for agricultural products and the resulting food prices; the major environmental effects; the impact on the structure of the agricultural industry; the quantities of alternative types of energy used on farms and in other parts of the food and fiber system; and the effect on other sectors of the economy. Furthermore, the model(s) should trace these effects through time rather than comparing the current situation with the static equilibrium at some future time.

Interregional programming models can provide several types of the information listed above. By considering regional availabilities of land and water resources, regional demands for agricultural products, and transportation from producing to consuming regions, the model estimates the regional distribution of production, the equilibrium food prices, environmental effects, and the quantity of alternative types of energy used in farm production and transportation. However, they provide little information on the impact at the farm level, regional employment, regional nonfarm income, and the impact on other sectors of the economy.

Simulation models can be developed to estimate the impact on other sectors of the economy. However, the difficulty of specifying the appropriate relationships and estimating the parameters will limit such development. As a result, both interregional programming and simulation models will be used. Two types of work should be carried out to complement these analyses.

One of the major problems with aggregate models that simultaneously select production systems for alternative regions is including enough detail on the relevant alternatives and constraints. Omitting the detail leads to broad shifts in the products and production methods, when resource constraints and production conditions on individual farms would lead to a very different adjustment.

Currently available models do not incorporate an adequate range of available technologies and possibilities of substituting one source of energy for another. Two types of tillage, the possibility of residue removal, and two levels of fertilizer do not adequately describe the production alternatives for a crop in many (perhaps any) areas. For example, changing from conventional to reduced tillage in the northern part of the Corn Belt affects not only the seasonal workload but also spring soil temperatures that affect the planting date, rate of plant development, and energy requirements for drying. Thus, the relevant system of production to include in an aggregate model must be selected considering the appropriate interactions.

The possibility of substituting one source of energy for another can be illustrated with estimates of energy requirements to dry 20,000 bushels of shelled corn from 26% to 16% moisture with currently available technologies. A Minnesota study indicates that high temperature drying requires 4,020 gallons of propane and 2,000 kilowatt hours of electricity, while a combination of high temperature drying from 26% to 20% and low temperature drying from 20% to 16% requires 1,860 gallons of propane and 10,400 kilowatt hours of electricity (Cloud and Walter).

These examples illustrate the need for detailed analyses of crop enterprise production

Vernon R. Eidman is a professor of agricultural and applied economics, University of Minnesota.

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systems at the firm level. Livestock systems should also be analyzed so that whole farm programming and/or simulation models could be used to select the product and technology mix for alternative price ratios both in the short run and after firms have had an opportunity to adjust their capital inputs. Representative farm models could provide input on the relevant production systems and constraints for aggregate models. The equilibrium prices determined with aggregate models could be used to evaluate the firm level impacts, including income level by size of firm.

My second concern is that the models consider embodied energy when evaluating alternative technologies. Estimates of embodied energy have been developed for many agricultural inputs, including selected categories of farm machinery (Federal Energy Administration; Doering, Considine, and Harling). However, estimates are needed for other categories of capital inputs, including other types of machinery, buildings, and livestock equipment. More detailed estimates of the embodied energy in these inputs are needed to properly evaluate the total energy requirements for alternative systems of production.

While Heady and Dvoskin have listed many areas for additional research, three seem to be particularly important. The combination of firm level and aggregate models is well suited to the analysis of each. The evaluation of alternative energy price scenarios with currently known technology is an obvious area of application. Using aggregate and firm level models in combination will provide information on regional production adjustments, product price impacts, energy demand, and firm level impacts.

Estimating the energy price levels and other conditions under which new technology will be adopted is a second area. In many cases firm level analyses will be sufficient. In some cases the impact may be great enough to justify an evaluation at the aggregate level.

The third area is the evaluation of changes in institutional arrangements to encourage energy efficiency. Are current investment credit and additional first-year depreciation provisions consistent with increasing energy efficiency? What additional incentives can be developed to encourage the agricultural sector to shift to more energy efficient processes? Much of the work in this area could be done using firm level models, although the aggregate implications should also be traced where significant changes seem likely. Analyses of such changes may suggest a reduction in the producer's ability to respond to uncertain production conditions, necessitating a careful examination of the uncertainties involved and the response of farmers to them.

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Energy Policy and Research in Agriculture

Earle E. Gavett

The United States faces an energy problem arising from increasing demand for energy and a dwindling domestic supply. The nation has become increasingly dependent upon the world oil market. At the time of the 1973 embargo, we were importing about one-third of our oil. Now oil imports total over one-half. Concern is mounting over the increasing dependence on the world oil market and our growing vulnerability to supply interruptions.

For these reasons the president presented to Congress a comprehensive National Energy Plan (NEP) (U.S. Congress). This plan was designed to reduce domestic demand for oil and for natural gas for nonessential uses through an effective conservation and fuel efficiency program in all sectors of energy use, through restructuring of utility rates and conversion by industrial firms and utilities from oil and natural gas to coal and other fuels. It stressed the need to develop renewable and essentially inexhaustible energy sources to insure sustained long-term economic growth. This plan contained six national energy goals for 1985: (*a*) reduction of annual growth of U.S. energy demand to less than 2% from the current 5.1% (Federal Energy Administration 1977b); (*b*) reduction of the level of imports to less than 6 million barrels per day —for the first half of 1977, total petroleum imports averaged 8.9 million barrels per day (Federal Energy Administration 1977a); (*c*) achievement of a 10% reduction in gasoline consumption from the 1977 level, which was 6.9 million barrels per day based on first half year data; a 10% reduction to 6.2 million barrels per day would be lower than the 1973 preembargo level of 6.7 million barrels per day; (*d*) insulation of 90% of all American homes and all new buildings (46% are uninsulated; we do not know the proportion that is adequately insulated); (*e*) an increase in annual coal production to at least 400 million tons over the 1976 production of 671 million tons of coal; and (*f*) use of solar energy in more than two and a half million homes, the equivalent of all U.S. farmhouses.

Agriculture's mission is to develop policies to assure a continuous and adequate supply of food, fiber, and forest products at reasonable prices for American consumers and for export. With U.S. and world population increasing at 0.6% and 1.8% per year, respectively, (Population Reference Bureau), agricultural energy needs are likely to increase. We must consider the impacts of agricultural policies on resource needs and how they conflict with NEP goals. For example, a strong agricultural export policy will increase the impact on land, water, and energy resources. Likewise, we must examine the implication to agriculture of achieving NEP goals.

Achieving NEP goals implies substantial modification of long-established trends in resource use by agriculture and rural residents. These shifts must be considered in formulation of agricultural and rural development policies and in the administration of public programs. Examination of some of the trade-offs between energy policy objectives and food policy objectives may lead to reconsideration of both sets of objectives. I look at some of the major issues concerning energy development and conservation and interfuel substitution.

Energy Development

A major aspect of the NEP is to develop energy from plentiful supplies like coal or from renewable resources like solar and agricultural products. This may lead to land, water, labor, and community problems. Developing western coal resources has direct local impact on strip-mined land but little total impact. As we develop southern Corn Belt coal, impacts on farm land and production will be substantially greater. How coal is utilized also affects land. If hauled by rail to eastern markets, the land impact is slight. If slurry pipelines are used, the impact is also slight. If mine-mouth generating plants are established, high voltage transmission lines will cross many acres of

Earle E. Gavett is with the National Economic Analysis Division, Economic Research Service, U.S. Department of Agriculture.

farmland, taking permanently out of production a fifth of an acre per mile.

Of greater importance is the impact on water use to agriculture. Irrigation is needed to revegetate mined land. Transporting coal east by slurry pipeline will consume a ton of western water per ton of coal moved. Moving 400 million more tons of coal a year by 1985 will require 400 million tons of water annually (AAAS). This is the equivalent of 295,000 acre-feet of water, sufficient water for 16% of Colorado's irrigated cropland. Mine-mouth generation of electricity takes even more water. One estimate is 4 tons of water per ton of western coal used per efficient 1,000 megawatt steam generation plant (AAAS).

Western coal development can raise havoc with the rural labor market. Heavy equipment machinery operators require similar skills to farm equipment operators. Energy developers can pay sharply higher wage rates. How will farmers obtain needed labor?

The sudden influx of energy developers places a great burden on rural communities to provide housing, schools, hospitals, roads, and other facilities. These services are required prior to obtaining revenue from any coal sales. Local and state budgets will be severely impacted unless front end financing is provided. Also, the structure of local governments may be inadequate to deal with complex issues involving powerful energy companies.

Agricultural use of a low-grade, nonconcentrated, interruptable heat source like solar has many attendant problems. Large collectors are needed; storage is vital for nights and bad weather; and conventional back-up systems may be required. The technology is in its infancy and is expensive. The high initial cost is the main cost. There are many agricultural opportunities for solar power—water pumping, crop drying, livestock brooding, rural home heating, etc. Can it be afforded?

Plantations of field or forest crops for energy to replace fossil fuels are proposed. These will require vast acreages of land as well as fertilizer, pesticides, labor, machinery, and water inputs. Crop and livestock residues used for energy generation may affect soil fertility, structure, and tilth and speed up wind and water erosion.

Conservation and Interfuel Substitution

The NEP places a major emphasis on conservation of energy, efficient use of fuel, and conversion to fuel sources that are renewable or plentiful. The strategy is to increase fuel prices through taxes and offer rebates for conversion to desired fuels. To conserve electric power and reduce need for new facilities, a complete restructuring of utility rates is proposed. To adopt conservation technologies that may not yet be economic, a system of rebates and tax credits is proposed.

Impacts of this segment of NEP upon agriculture and rural America are many and diverse. What are the possibilities for interfuel substitution by agricultural firms? What are the consequences? Impacts often are energy source specific, so this paper addresses the issues by energy type.

Natural Gas

The food and fiber system uses natural gas for about one-third of its energy needs. In the processing industry it is over half. Fertilizer manufacturing used natural gas for over 90% of its energy. The NEP exempts agricultural uses, including irrigation pumping and feedstock for making anhydrous ammonia, from the oil and gas consumption tax but not for process heat use in fertilizer plants, food processing, and marketing.

Southwestern farmers have been shifting away from using natural gas to electricity for pumping irrigation water as gas increased in price and delivery was not assured. By 1985 Sloggett visualizes natural gas being denied for irrigation pumping requiring conversion of some 100,000 pumps. Southwest Electric Power Pool reserve generating capacity is expected to be only 13% by 1985 (Energy Resources Council). This is inadequate for accepting many large agricultural users having peak seasonal needs coincident with household and nonfarm business peaks. Further compounding the problem are interfuel conversion requirements for these generating plants.

Nonfarm agricultural industry must also convert to coal, electricity, or other sources. The financial impacts on highly seasonal operations such as fruit and vegetable processing plants may be so severe as to force termination of operations. Some may pay the taxes rather than incur the conversion cost.

Cost increases to fertilizer, chemical, and farm machinery manufacturers will likely be passed on in product costs to farmers. In shortage situations, such as the 1976–77 winter, vital food industries will also have gas

curtailed. Alternative fuels such as liquefied petroleum gas will be needed to prevent impacts from farmer to consumer.

Gasoline and Diesel Fuel

Gasoline and diesel fuel prices will be 10% to 20% higher as a result of the crude oil equalization tax and adversely affect rural residents who are personal vehicle dependent. Rural development may also be affected as rural areas are heavily reliant upon the trucking industry. Diesel price increases will be translated into higher costs for goods delivered to and from rural areas. This may disadvantage distant production areas.

Energy needs of farm producers and processors are unpredictable, being heavily affected by climatic conditions. This compounds fuel distribution problems. During the embargo, fuel distributors abandoned service to farmers and residents in remote areas. As fuel costs increase, the remoteness, unpredictability, and small capacity of rural accounts makes fuel delivery service more costly, and we may see increased abandonment.

Electricity and Coal

Conversion from oil and natural gas use to electricity will require land for transmission lines, water for steam generation, capital to convert equipment from oil and gas, and development of a reliable electric power grid distribution system. Higher rural electric rates are likely. Restructuring rates to eliminate promotional and block rates and introducing time-of-day metering, seasonal, and interruptable rates present many and varied impacts to agriculture. Must farmers irrigate only at night? Have they sufficient pump capacity? What is economical?

Conversion of agricultural processing and manufacturing plants to coal is capital intensive. New boiler costs including environmental protection equipment have been rising in excess of 8% per year. Many processing plants are located in production centers distant from coal supplies, requiring new fuel distribution systems.

Research Needed to Meet Both Energy and Agricultural Goals

Policy makers are interested in maximizing positive and minimizing negative impacts of alternative policy actions. One can not assess the impacts of a complex energy program on agriculture and rural America unless one understands the current patterns of energy use and the socioeconomic and environmental conditions that govern citizen response. It is vital to have a detailed, accurate data base on energy use in the food and fiber system and for rural living and rural development. Data must be valid at the state level. State conservation plans are currently being developed based on grossly inadequate energy use data.

Resource needs for energy development must be assessed against rural community and agricultural needs. Many of the energy problems transcend state lines, and policies developed will have local, state, regional, and national implications. They must be addressed by researchers at these levels. Let me be specific on a number of items.

Irrigation uses one-eighth of farm production energy. Economic assessment of water use is vital to agriculture. How much water is needed? At what price? How can it be applied more efficiently? Can we afford solar pumps? Can irrigated agriculture and energy development both survive in the West? Or should more food production occur in the East under supplemental irrigation?

Food processing takes twice the energy of production. How can we reduce energy costs and dependence on scarce fuels and satisfy consumer wants? Can the refrigeration and packaging demands be reduced? At what level of energy costs will new technologies be attractive, restructuring of product mix occur? Which producer group will be most affected?

Will increased energy costs force relocation of production and processing closer to consumers? What would be the impacts of such shifts? Can farmers market products direct to consumers? How can rural areas develop as energy costs increase? Can people afford to live there, work there?

Should agriculture, or just food production, receive top fuel priority? Should it get subsidies to reduce impacts of higher prices? How does this affect conservation and conversion to other fuels?

What are the prospects for energy production from agricultural materials? Can segments of agriculture be made energy self-sufficient? Would they be economically viable? Can we find the necessary large blocks of land?

How can the livestock industry be made more energy efficient? What are the economics of reducing high energy inputs to cattle and hogs?

If electricity is the energy source of the future, how can agriculture and rural America best use electricity? In striving for NEP goals of energy development, how can the adverse impacts on land, water, and transportation systems be minimized? Should there be national water and transportation policies?

A strong balanced research effort must be mounted now to address important agricultural and rural energy issues if we are to have any input in shaping the future for agriculture and rural America. Many of the issues are complex and require a multidisciplinary approach for solution. The following is one approach. The U.S. Department of Agriculture and the Energy Research and Development Administration (ERDA), recognizing the complexity of the issues, their varied responsibilities, and the research talents needed, developed a USDA/ERDA Memorandum of Understanding for the development and implementation of a National Program of Agricultural Energy Research, Development, and Demonstration (National Planning Committee). The Memorandum of Understanding calls for this jointly funded national program to be conducted in large part by the publicly supported agricultural research and technology transfer system—the land-grant institutions and the USDA.

How these agencies, having overlapping responsibilities but different goals, actually meld complex research, development, and demonstration issues into a comprehensive national program is of concern. They have different perspectives that I perceive as follows. ERDA's approach has been one of developing high technology in large scale operations with a limited number of adopters. It works closely with industry. Once a working model is developed, it relies upon industry to disseminate. Timing is more important than cost in its research program. The USDA's approach has been to strive for economic and technical efficiency and yet maintain small family farms. It serves a wide range and size of firms. It works closely with state agricultural experiment stations with little industry involvement. Technology transfer is mainly by extension service staff. Research activities tend to be modest with cost a paramount factor.

I challenge agricultural economists to participate as fully as possible in the development of this national program. You, in turn, should challenge these agencies when you perceive that they are taking the wrong approach. By such interaction we will likely develop a better program to aid policy makers and improve the future for agriculture and rural America.

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Energy Policy and Research: Discussion from the USDA Perspective

Ralph J. McCracken

Gavett presented well the differences perceived between the Energy Research and Development Administration (ERDA) and the U.S. Department of Agriculture (USDA) approaches to energy research. As he indicated, ERDA concentrates on rapid development and early commercial adoption of research-derived technology. The USDA and its state agricultural experiment station (SAES) cooperators spend more time researching a topic and solving most technical problems; only then is a project released for information, technology transfer, and commercial adoption.

This difference in approach and the designation of ERDA as the federal lead agency for energy research has resulted in funding problems for the USDA. Specifically, the USDA does not receive enough funding from ERDA "pass-through" energy research funds to do its traditional thorough kind of research. Under the ERDA "rapid-development" approach funding is limited, is necessarily short term, and lacks continuity. This implies no criticism of ERDA. At the same time, however, the USDA has not been able to fund an energy research project from its own research budget because, under the ground rules set by the Office of Management and Budget, most funding for energy research must pass through the lead agency. General USDA research funds are heavily committed to other high priority research needs (level funding). In fiscal year (FY) 1977, $2.7 million in ERDA energy research funds will pass through ERDA to the USDA and cooperative SAES's under the lead agency concept, but these will be the only "new" funds the USDA will receive in FY 1977 for energy research projects. The USDA has special difficulty in funding those projects that are partially energy related. So, it has ended up with a relatively small amount of "continuity" funding for energy-related projects, all acquired by redirection of funds from other priority research areas in a period of level research funding—constant dollar basis.

Why do the USDA and SAES's specifically need continuing base funding for energy research? The answer is that they must have resources in place to respond to new research needs and to be able to apply incremental funds to their followup, that they must be able to plan and conduct research more effectively, and that they must carry on associated and related research leading to the development of new or modified food production or processing systems that are built around the new energy sources.

But this funding problem is on its way to resolution. I am confident that the ERDA-USDA Memorandum of Understanding, which Gavett discussed, will do much to solve this. Secretary of Agriculture Bergland has a strong interest in energy research. There have been recent positive discussions with ERDA officials about the need and responsibility of the USDA (and its cooperators) to research the systems adjustments needed to use solar technology in agricultural production and processing.

Meanwhile, there are lessons to be learned. We in the agricultural research community need to seek ways to become more rapidly responsive to high priority national research needs that are partly outside the agricultural sector. Especially, we must learn how to move new technology, as components of systems, into actual application more rapidly. Becoming more rapidly responsive to priority needs for new technology suggests certain policy changes: applying new techniques in project (matrix) management; improving interagency, federal-state coordination mechanisms; and finding new and more effective ways of redirecting existing programs and absorbing incremental funding like that received from ERDA. It means accepting and working with

Ralph J. McCracken is the associate administrator with the Agricultural Research Service, U.S. Department of Agriculture.

other agencies and organizations (including working with the lead agency mode), in other words, avoiding a "closed community" attitude in agricultural research.

I agree with Gavett's statements on energy research needs. I would add (*a*) greater emphasis on irrigation conservation practices, including efficient irrigation scheduling, use of less energy-intensive methods and economic analysis of center pivot versus other systems; (*b*) greater emphasis on tillage conservation and other energy-conserving crop management practices, especially extension of minimum tillage to the northern Corn Belt; (*c*) more efficient use of energy-intensive nitrogen fertilizer and use of less energy-intensive fertilizer and pest control practices; (*d*) reexamination of previous work and new research on organic matter and residues; (*e*) continued work in bioconversion on more precise predictions of role of crop residues in different soil and environmental situations (energy, erosion control, fertilization); (*f*) development (including economic analysis) and modification of production and processing systems for insertion of new energy sources; (*g*) analysis of the "biological imperatives" in economic and policy analysis, e.g., the importance of timely planting and harvesting and the associated high demand for and value of energy at these times, and (*h*) more emphasis and research on energy conservation and interfuel substitution on the postharvest side of the food system.

Looking ahead, reclamation research will loom large in the pass-through funding arrangement with the Environmental Protection Agency and ERDA and in in-house support with the recent strip-mining reclamation legislation.

In closing, I join in Gavett's challenge to agricultural economists to participate more fully in agricultural energy research. We in the physical and biological science sectors of agricultural research have not solicited your involvement and cooperation as aggressively as we should. There are many interesting research possibilities for you. Your help is badly needed in finding solutions to one of the nation's highest priority problems.

Energy Policy and Research: Discussion from the ERDA Perspective

Stanley J. Clark

To achieve the objectives of the president's National Energy Plan, all segments of the economy must do their part, and agriculture is no exception. The National Energy Plan must serve as the framework for establishing agricultural energy policy and research goals.

I agree with Gavett that reducing the annual energy demand growth rate of the agricultural industry will be difficult. However, analyses by the Energy Research and Development Administration (ERDA) show that increasing the efficiency of energy use can have the greatest immediate impact until about the year 2000. Improved energy use efficiency in animal and crop production; feed and grain handling and transportation; food processing; food packaging, handling, and transportation; and food preparation should therefore be the number one priority. This certainly does not mean forgetting about alternate energy sources. Due to the long development times for difficult new technologies, their major energy contributions will occur after the turn of the century. Research and development effort must therefore be pursued vigorously today.

The overall efficiency of energy use in the agricultural industries depends on how well systems analysis techniques are applied to each energy-intensive enterprise in the agricultural industry. Such an analysis does the following: defines the total system bounds; analyzes material and energy flows across the system boundaries and across each process within the system; determines energy use efficiency across each process or unit operation within the system; performs environmental, reliability, and safety analysis for proposed system changes; and performs economic analyses for proposed system changes.

If a systems analysis approach is not used, we will get at best piecemeal solutions and many reoccurring problems. Examples of problems are: a gain in energy use efficiency across one process in the system may result in a decrease in energy use efficiency for the total system; environmental, reliability, and safety considerations will not be properly addressed; and system changes suggested for saving energy or substituting alternate energy sources may not be economically viable.

In my opinion, water use should also be a part of the systems analysis. In many cases it is already included in such studies. Decreased energy use in irrigation systems can be most easily attained by pumping less water on the crop or decreasing the crop consumptive use.

The U.S. Department of Agriculture's (USDA) food and fiber production responsibilities have been outlined by Gavett. ERDA has indeed recognized the need for specific research, development, and demonstration (RD&D) programs that relate to the production of food and fiber. ERDA has specific programs dealing with the application of energy conservation technology to agricultural production and food processing. It also has specific programs dealing with biomass energy production and the use of solar energy, wind, and waste heat in agricultural production and food processing. Program needs are reviewed each year within each ERDA division. The major portion of most RD&D programs is performed by contractors. The contracts result from unsolicited proposals, program opportunity notices, program research and development announcements, and requests for proposals.

The Agricultural Production and Food Processing Branch of the Industrial Energy Conservation Division is attempting to establish RD&D programs for the most energy-intensive activities (irrigation, crop drying, fertilizer production, processing and packing, etc.). Emphasis is also placed on establishing RD&D programs for enterprises in agricultural production where energy costs are a significant percentage of total production costs.

Stanley J. Clark is the program manager with the Industrial Energy Conservation Division, Energy Research and Development Administration, Washington, D.C.

The Industrial Energy Conservation Division has conducted workshops in production agriculture, food processing, and waste heat utilization to assist in determining research needs and corresponding priorities. The Division has published reports from these workshops, which are available from the Technical Information Center, Oak Ridge, Tennessee, and is currently reviewing the workshop proceedings thoroughly and preparing publications that will indicate how ERDA has responded to the workshop suggestions. The Division firmly believes that feedback such as this is invaluable to ERDA's program.

In 1910 2 calories of cultural energy were used to put 1 calorie of food on the plate. In 1970 9 calories of cultural energy were used to place 1 calorie of energy on the plate. This trend must be reversed if the challenge of a decreasing energy supply and an increasing demand for food is to be met. Governmental agencies and private industry are going to have to cooperate much closer than they have in the past to meet this challenge. Duplication of effort must be minimized, current technology must be fully utilized, development of new technology must be accelerated, and technology transfer time lag must be minimized.

The forthcoming Department of Energy and the USDA are the two most important governmental agencies involved in the food-energy problem. Gavett referred to an ERDA-USDA Memorandum of Understanding that has been enacted to promote full cooperation between the agencies. Hopefully, the Memorandum will assist in determining program priorities, prevent duplication of effort, make possible full utilization of the strengths of both agencies, and provide the mechanism for cooperative research coordination and planning.

In conclusion I reiterate what Gavett has said: get involved in energy-related projects. We need the expertise of agricultural economists in trying to meet the challenge of the energy-food problems facing us in the near future.

Energy Policy and Research: Discussion from a Land Grant Institution Perspective

Henry R. Fortmann

Members of the agricultural research community of land grant institutions have deep concerns about agricultural energy. It is both logical and appropriate that they are concerned about energy policy and research as they affect agriculture. They do not make policy, but they do have both the capacity and the mandate to conduct research. My comments center on four points.

First, there is no energy need, local or national, more important than maintaining an adequate, reliable supply of energy for agriculture. This does not deny that certain other energy uses are also important. We can improve efficiency and shift to other forms. But unless we adequately produce, process, and distribute food and fiber, all our other goals, aspirations, and dreams are without point; in short, we will all "have had the course." I dismiss the suggestions that we revert to a labor-intensive agriculture.

Second, the research and development to eventually make this nation appropriately self-sufficient in agricultural energy will be done by a combination of performers: (*a*) the existing publicly supported research system, (*b*) other public and private research institutions, agencies, etc., (*c*) foundations, (*d*) industry, and (*e*) individual entrepreneurs. Data on research capacity are available only for the existing publicly supported agricultural research system (*a*). It is the only system that can tell you "who is doing what, where, how, and why?" Not only can it tell you but it regularly does in useful, logical, and systematic ways. It is organized to plan, cooperate, and coordinate research and to identify priorities and future needs.

Third, research is done by individual scientists. The superstructure of administrators, the bureaucratic hierarchy, the gaggle of "project-proposal writers," peer reviewers, and Office of General Council and Office of Management and Budget officials can contribute. They can expedite obtaining the resources necessary to carry on research. On the other hand, they, along with Congress, the Occupational Safety and Health Act, Environmental Protection Agency, Office of Civil Rights, and others, can aid and abet the proliferation of rules and regulations that can impede the conduct of research.

I concur with a concept expressed by Schultz, "But in fact a large organization that is tightly controlled is the death of creative research, regardless of whether it be the National Science Foundation, the U.S.D.A. [U.S. Department of Agriculture], or any other federal agency, a large private foundation, or a research oriented university. No research director in Washington can know the array of research options the state of scientific knowledge and its frontier can afford" (pp. 7–8). However, I am totally supportive of avowed intentions to reason together, plan together, and coordinate efforts so as to optimize use of available resources.

I also want to underscore a portion of the Memorandum of Understanding between the USDA and the Energy Research and Development Administration (ERDA) concerning agricultural energy research, development, and demonstration: "Section IV. Implementation. D. Insofar as possible, agricultural inputs into National Program development, implementation and review will reflect, but not be restricted to, the total system of publicly-supported agricultural research, development and technology transfer. . . . Further, the Steering Committee will encourage Land Grant university representation on the Steering Committee, the Working Committee and the Subject Matter Groups" (p. 3).

R. Dennis Rouse, chairman of the Experiment Station Committee on Organization and Policy (ESCOP), has named such a representative. This is the unequivocal signal by ESCOP, that the fifty-six state agricultural exper-

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Henry R. Fortmann is the regional coordinator with the Northeast Association of State Agricultural Experiment Stations, Pennsylvania State University.

iment stations are ready to serve and expect to participate in the process of directing our destiny through helping formulate and implement a course of agricultural energy research and development.

Fourth, the report to the National Planning Committee of the Agricultural Research Policy Advisory Committee, "A National Program of Agricultural Energy Research and Development," contains three parts: the current situation, the plan, and recommendations for the future. The plan and the recommendations for the future are but a framework for moving ahead. They contain no cure-all solutions for the agricultural energy needs. They do delineate examples of problems and constitute the first iteration of a workable system to classifying agricultural energy research and development. Land grant scientists must devise the vehicles to solve the problems. The administrative structure and the Congress must provide the resources. The state agricultural experiment stations can do no less than commit themselves to full participation in the process. The future of this country, and indeed of mankind, demands that they be enabled to do so and that they do.

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Symposia

Forecasting Methodology Update. Bruce Scherr, chairman (Data Resources, Inc., Mass.), William E. Kibler (SRS, USDA), Robert MacDonald (National Aeronautics and Space Administration, Houston), J. B. Penn (Council of Economic Advisers, Washington), James Liebfried (Canadian Wheat Board, Winnipeg), Dale B. Berkheimer (Sperry New Holland, Penn.), and Donald Schwartz (Cargill Investor Services, Chicago)

The volatility of worldwide agricultural commodity markets over the last five years has catalyzed a strong interest in forecasting agricultural supplies, demands, and prices. There has been a great deal of work by public and private organizations in refining and better communicating production, demand, and price forecasts. New technological developments, such as satellite tracking of crop progress, have been underway that should serve to supplement existing Statistical Reporting Service's production estimates. Furthermore, the requirements imposed by the new federal budget process in evaluating farm legislation costs and impacts have broadened the use of agricultural commodity forecasting activities across many agencies outside the U.S. Department of Agriculture. The use of baseline forecasts with alternative scenarios that define a series of risks around the base forecast have provided policy makers with a very detailed information set concerning the extent of government involvement in farm programs. Agribusiness forecasting work has also progressed dramatically in recent years by utilizing forecasting tools for planning purposes that cover a broad range of corporate needs, in particular, forecasting agricultural activity as it influences product-line sales, market share, purchasing plans, and other detailed firm informational needs.

Alternatives to the Debt-Free, Owner-Operated, Family-Sized Farm. Don Paarlberg, chairman (Purdue University), Edward W. Sparling (Colorado State University), Harold F. Breimyer (University of Missouri), and Kenneth E. Frick (Bakersfield, Calif.)

The debt-free, owner-operated, full-time, family-sized farm has been an ideal in much of America since earliest times. Increased size of farm, larger capital requirements, and changing structural concepts have made it increasingly difficult to hold to this old ideal. New structural forms are developing: leasing, perpetual debt, part-time farms, incorporation, vertically integrated farms, very large "family" farms, and farming enterprises of nonfarm corporations. Each of these organizational forms was discussed in this symposium.

Generally, this was the prevailing concept of the family farm: a farm with entrepreneurship in the hands of the operator, hiring not more than two man-equivalents. Pertinent issues raised were: What are the respective efficiencies of the various institutional forms? (The "family farm" came off rather well in this discussion.) Is land simply an input item, a means of earning income, like other production goods? Frick thought yes. Breimyer and Paarlberg thought no. Disputed issues were: Should large farms be passed intact from one generation to another? Do we want a hereditary land-owning class? Should the owner receive the unearned increment in land values resulting from inflation and from the scarcity factor associated with population growth? There was agreement on one point: if the body politic could decide what kind of farm structure was desired, it would be possible, through public policy, to tilt toward that type.

Impact on Rural America of the Federal Water Pollution Control Act Amendments, PL 92-500. Lee A. Christensen, chairman (ERS, USDA), C. Edwin Young (ERS, USDA), G. A. Carlson and James A. Seagraves (North Carolina State University), Wesley D. Seitz (University of Illinois), Clyde F. Kiker (University of Florida), Lawrence W. Libby (Michigan State University), and Thomas Waddell (Environmental Protection Agency)

PL 92-500, particularly the water quality requirements, has major implications for U.S. agriculture. It impacts rural communities, land use, the agricultural processing sector, and crops and livestock production. The high costs of upgrading the level of wastewater treatment in rural communities is influenced by significant economies of size in wastewater treatment. The increased emphasis given land application of wastewater provides rural communities an economical method for advanced wastewater treatment but also raises competitive land use issues.

The location and operation of agricultural processing plants is influenced by the cost-sharing provisions of the law. The present subsidy system provides a strong incentive to buy capital-intensive systems and expensive designs, often leading to suboptimal decisions. Industries often treat their own wastes rather than hook on to municipal systems due to high costs and cost recovery programs. Investment in waste treatment systems in arid states, which previously had little need for expensive waste treatment plants, has increased substantially.

A third set of impacts relates to the control of erosion and sedimentation required (section 208). An analysis found that reasonable soil loss restrictions do not have adverse economic impacts but stringent soil or nitrogen restrictions do. Farm income generally increases at consumer expense. A watershed model of the long-run impacts of soil erosion indicated a complete loss of topsoil in the

Corn Belt within 100 years if present practices are continued. Farmers cannot be expected to implement soil loss controls without subsidies.

A spirit of "ethically inspired voluntarism" would help economists have more impact on environmental policy formulation. Legislation comes out of a technological and legal mind set. The Environmental Protection Agency often goes to technical solutions because of the transactions and implementation costs of nontechnological solutions. Economists typically take a broader view of problems and sometimes appear to be uncompromising but can make real contributions in developing economic compromises.

Private versus Public Organization of U.S. Grain Exports, Paul L. Farris, chairman (Purdue University), Clarence Palmby (Continental Grain Co., N.Y.), Alex F. McCalla (University of California, Davis), Andrew Schmitz (University of California, Berkeley), Lauren K. Soth (Des Moines Register and Tribune, Iowa), Robert Handschin (Farmers Union Grain Terminal Association), Lowell D. Hill (University of Illinois), and Gary G. Storey (University of Saskatchewan)

The policy issue addressed is the institutional organization of the U.S. grain export system. The primary advantage of the prevailing U.S. system, in which large private grain exporting companies play a central role, appears to be the unique ability of private companies to match grain supplies and demands effectively and efficiently in accordance with market conditions. Nevertheless, the world market for grain is not a classical free market. Large grain traders may be in positions to influence grain trading and government export policies in such ways as to favor themselves relative to U.S. farmers and consumers. U.S. bargaining ability might also be disadvantaged by the centralized control exercised by most foreign governments over their own grain buying and selling in international markets, while no centralized agency handles grain marketing in the United States.

Comparisons between the Canadian and U.S. grain marketing systems showed U.S. production to be ten times larger than Canadian and more diversified in terms of crops grown and the dispersion of production areas and markets. Grain production and exports have grown absolutely in both countries, but the relative rate of growth has been higher in the United States. The lead in developing grain handling technology has come from the United States. The Canadian system emphasizes equity considerations of pooled prices, equal market access, and known marketing margins and places less emphasis on the role of the individual and firm than does the U.S. system, which is premised on free market efficiency goals.

The marketing systems are unique functions of the socioeconomic history of each country, with cooperatives and the Canadian Wheat Board (which has a monopoly on export sales) playing major roles in Canada, while private firms are more important in the United States. Grain marketing systems are not necessarily transferable among countries. Policies for improving the U.S. system will likely be most successful if they recognize and build upon basic characteristics of the U.S. economy and socioeconomic values of U.S. citizens.

Small Farm Oriented Agricultural Policy. W. Arden Colette, chairman (University of Florida), Chris O. Andrew (University of Florida), Eldon D. Smith (University of Kentucky), and Charles D. Whyte (Virginia State College)

A broad definition of the small farm based on annual gross sales may be useful for policy direction, but a more specific delineation of audience characteristics is necessary to identify audiences and develop specific programs. Societal and individual goals must be considered. Profit maximization and economic efficiency may not be the principal criteria for developing and evaluating program success. Stability, security, and family well-being rank very high in the small farmer's goal structure. We must determine not only the values, beliefs, goals, and aspirations of individuals in the target audience but also production and marketing behavior and must design programs to encourage the greatest possible change within the small farmer's environment.

Even if self-sufficiency is not attained, both the individuals and society benefit from programs for small farmers. Increases in farm income result in increased tax revenues, offsetting program costs. Government expenditures incurred as welfare payments would not have similar effects. Raising the education and training level increases the alternatives for off-farm employment. Since the majority of black farmers operate small units, the impact of declining economic position of the small farm is more evident in the black population. Special programs may be necessary to address problems of the black small farmer.

Changing either the economic conditions or the characteristics of the small farm audience requires considerable time, effort, and financial assistance. It is important that Congress and state legislatures not be misled into thinking that increased funding over a short time period will solve the problems. Such high expectations could result in disappointment and failure of the overall program.

Economics of Integrated Pest Management. Arnold L. Aspelin, chairman (Environmental Protection Agency), K. L. Reichelderfer (University of Maryland), Darwin C. Hall and Andrew P. Gutierrez (University of California, Berkeley), James E. Casey (Oklahoma State University), Joseph C. Headley (University of Missouri, Columbia), Hovav Talpaz (Texas A&M University), David W. Parvin, Jr. (Mississippi State University), James Stewart (Pest Management Associates, Calif.), and Jake MacKenzie (Environmental Protection Agency)

An economic evaluation of alternative pest man-

agement strategies utilizing simulation modeling that focused on the Mexican bean beetle and simulated an intraseasonal dynamic system was presented by Reichelderfer. The profitability of integrated pest management was examined by Hall using case studies for cotton and citrus in the San Joaquin Valley. Conventional pest management strategies were compared for profitability, pesticide use, crop yields, total expenditure, and risk. Casey presented a paper evaluating selected pest management strategies in Texas cotton production. Opportunities for integrated pest management exist for developing production management strategies to deal with cotton pest problems. Headley presented an evaluation of alternative pest control technologies for grain crops and soybeans. The relative importance of chemical pesticides, mechanical methods, biological methods, and cultural methods throughout 1978–92 in these U.S. crops were discussed. Talpaz presented a composite model of the boll weevil-cotton crop system, incorporating three independent developmental time scales: weevil development, fruit drying, and cotton plant development. Sensitivity analysis showed that timing of pesticide applications is moderately sensitive to a change in pesticide price and highly sensitive to a change in the price of cotton.

A discussion lead by Aspelin as moderator, including Parvin, Gutierrez, Stewart, and MacKenzie drew the following conclusions. Risk under integrated pest management is quite variable, while pesticide usage averages out this risk. Variability of yield as well as long-term average yield needs consideration. Institutional support is required in research and training; a multidisciplinary thrust is needed (economic biological analysis must be incorporated early in the planning and implementation stages as well as after the program has been implemented). Council on Environmental Quality recommendations are in line with President Carter's message on environmental quality, which recommended that the federal government encourage the development of pest management techniques that emphasize use of biological controls, relying on chemical uses only as needed.

USDA Crop Reports: How? How Good? William E. Kibler, chairman, Charles E. Caudill, Robert A. McGregor, and Bruce M. Graham (SRS, USDA)

The technology used in producing crop reports has advanced dramatically during the last two decades. The Statistical Reporting Service (SRS) uses both area frames and list frames in selecting samples for agricultural surveys. The area frames have been improved in a series of steps from the master sample of the 1940s to the 1977 model, which is stratified by land use and updated to incorporate changes revealed by remote sensing. A list frame of all farm operators is now being developed with the aid of sophisticated computer software. Illustrations were given of the dramatic gains in efficiency resulting from the use of the superior but costly new area and list sampling frames.

The step-by-step data collection procedures used in SRS surveys were illustrated by a series of slides related to the corn production reports. Comparative advantages of both traditional nonprobability mail survey and modern probability survey techniques were noted. The flow of data was traced from the farmer or field observer to review by Crop Reporting Board and assembly into a national crop report. Review techniques for both speculative and nonspeculative data were illustrated by examples of actual summarized data and Board action. The power of aggregated regional data to improve upon the simple summarization of data from individual states was demonstrated.

Several measures of the quality of U.S. Department of Agriculture crop estimates were discussed. Handouts were used in making comparisons of early season forecasts with final estimates over an extended period of years. The number of monthly forecasts higher than the final estimate is about the same as the number lower than the final estimate. The deviations of the monthly forecasts tend to diminish as the crops move toward maturity.

Agricultural Business Curricula and Industry Needs. William Herr (Southern Illinois University), Carl W. O'Conner (Oregon State University), and Walter M. Meyers (ContiCommodities Services, Chicago), chairpersons, R. Stuckey (Santa Clara University), Leroy Davis (Southern University), W. David Downey and E. C. Oesterle (Purdue University), Phillip Sisson (Quaker Oats, Chicago), Carl R. Saathoff (Kroger Co., Cincinnati), and T. M. Hammonds (Food Retailing Institute, Washington)

Agricultural business programs for undergraduate and graduate majors (including the M.B.A.) were discussed. Emphasis focused upon courses and material that would prepare the student for solving problems and making decisions. Among courses meeting this objective were economic theory, statistics, business and government policy, law, finance, and marketing. The importance of entry level skills such as sales, accounting, or personnel supervision was discussed. Establishing rapport and involving the business community in the agribusiness program through internships, exchanges, field trips, presentations, and advisory councils were suggested as requirements for developing a strong program. Coping with a changing environment resulted in suggestions for greater emphasis on foreign trade, monetary policy, regulatory laws, and meteorology. Agricultural business curricula should help the student develop thinking patterns and attitudes about management and decision making. Flexibility is needed along with more information so that the system for educating and employing students in agribusiness can function more effectively.

Distribution Effects of Natural Resource Policy. Harry W. Ayer, chairman (ERS, USDA), Robert B. McKusick, Gerald Horner, and Daniel Dudek (ERS, USDA), Don Reading (Idaho State University), John E. Keith (Utah State University), Craig Infanger (University of Kentucky), Kenneth Scott (California Polytechnic University), Marilyn Altobello (University of Arizona), and Richard Adams (University of Wyoming)

Natural resource agencies of the federal government currently spend $17 billion annually—5% of the entire federal budget. The programs and policies of these agencies almost certainly affect the distribution of real income among income classes of people. In the papers, current and future natural resource policies likely to affect income distribution are discussed, and old and new empirical methodologies for distribution research are evaluated. Five papers then report on recent empirical studies of the distribution effects of particular natural resource policies. Forest and range policies in an area of Arizona are evaluated by input-output methods to estimate their impact on employment of different income groups. The impact of a reservoir project in Washington on income distribution of both farmers and recreationists is estimated. Another study utilizes linear programming to investigate the impact of water quality regulations, both management and pricing policies, on the distribution of income among income classes of irrigation farmers in California. An econometric model of the New England sea scallop fishery is used to estimate distribution impacts of the Fishery Conservation and Management Act of 1976. A final paper estimates the distribution impacts of alternative energy policy, both price increases and quantity restrictions, which may affect California agriculture. Quadratic programming, a method accounting for both changing energy and product prices, is employed. The papers demonstrate the importance of the distribution problem, research methodologies, how particular policies affect distribution, and policy conclusions and suggest pressing research needs. Also, all papers give key references.

Management of Nonmetropolitan Governments. Fred J. Hitzhusen, chairman (Ohio State University), Alvin D. Sokolow (University of California, Davis), John W. Malone (Pennsylvania State University), Paul H. Gessaman (University of Nebraska), and Gerald Doeksen (ERS, USDA)

There are over 50,000 nonmetropolitan county, township, and special district governments in the United States serving a growing population. Policy making in these governments is mainly a function of elected governing boards characterized by a commitment to unanimity at virtually any cost, adherence to the status quo, emphasis on personal and informal government, and limited policy specialization. The behavior of administrators and other employees of these nonmetropolitan governments is generally very informal.

Citizen-consumers have expressed varying degrees of satisfaction with the services provided by nonmetropolitan governments. A recently completed survey in four Great Plains states found the level of discontent over existing services not generally high, rural households supplying privately many services that are publicly provided in an urban setting, and, with the exception of health care, services delivered through interactions between individuals most subject to criticism.

Pennsylvania State University has a long-standing local government extension program including correspondence courses, special circulars, and handbooks. The program emphasis is on the legislative problem-solving process, the interrelations of public agencies and private institutions, the roles of the democratic process and dispersion of political control, and the significance of size and density of population in the financing and control of public services. Since late 1974, the Economic Research Service has been involved in a project to provide economic analysis for nonmetropolitan government decision making in the Great Plains. Research has included budget studies of alternative delivery systems for specific services, optimum location of certain services, and impact studies and projections. Considerable need exists for additional research and extension activity in the management of nonmetropolitan governments.

Returns to Land in the Corn Belt, Government Crop Price Guarantees Based on Cost of Production, and Land Values. John T. Scott, Jr., chairman (University of Illinois, Champaign-Urbana), Franklin J. Reiss and Steven T. Sonka (University of Illinois, Champaign-Urbana), Michael O. Boehlje (Iowa State University), and Marshall Martin and Bob F. Jones (Purdue University)

Costs of production on different sized grain farms for 1976, including both fixed and variable nonland costs, were presented in relation to the price of corn and target prices. The residual between costs of production and target was analyzed to estimate the price of land the residual would support. Lease arrangements were discussed, indicating the variation in returns that would be available as payment to land on different qualities of land and when land is on crop share or cash lease. An important policy question is whether and to what extent a return to land should be included in the costs of production used for calculating target prices. A simulation model shows that, if a return for land is included in the cost of production, spiraling land prices will occur. In fact, from the first to tenth year, land prices would approximately double, due mainly to the inclusion of a 3.5% return to land in the target price that causes a ratchet effect. The advantage for large farms would be greater than for small farms, resulting in increased financial ability of large farms to bid higher for additional land than small farms could. This would likely increase the concentration of land ownership and economic power in agricul-

ture into fewer hands. This would be in contrast to past policies in this country of attempting to stimulate a wide distribution of land ownership. It may become necessary in the future to make a greater distinction between land ownership, the various benefits of owning land, and the distribution of land ownership versus the rights to operate farm land and distribute the production from that land.

New Arrangements for Involving the Profession in International Agricultural Development. Charles E. Hanrahan, chairman (ERS, USDA), D. Woods Thomas and John W. Mellor (Agency for International Development), and A. T. Birowo (Agricultural Economic Survey, Indonesia). Abstract prepared by Thomas H. Lederer (ERS, USDA)

New arrangements for professional involvement center on opportunities in Title XII legislation and in policies evolving at the Agency for International Development (AID). These conclusions emerged: a need for human capital development in the less developed countries (LDC's) and the United States, a need for institution building in the LDC's, a recognition of the long-termness of development and the related need for long-range efforts, a recognition of mutuality of interests between LDC's and the United States, and a need to improve country-specific technical expertise within U.S. and LDC organizations. Thomas spoke optimistically about Title XII, indicating that it reflected present thinking about and future needs for long-term professional and university involvement in the development process. Mellor addressed the need for institutional capacities in the LDC's and the United States as a basis for desired technological change. He traced the evolution of AID policies from the emphasis on growth to present concerns for equity. Recognizing that helping the "poorest of the poor" appears to conflict with such investments as agricultural research, he stated the need for a synthesis of growth and equity policies. Birowo provided an LDC perspective stressing the relevance of development in the research and publications of the profession. He pointed out the deficit of experts trained in country-specific development issues and suggested a quantum increase in training of development-oriented professionals in the United States and the developing countries.

Economic Regulation in the Milk Industry: Estimated Impacts and Future Policy Prospects. Robert E. Jacobson, chairman (Ohio State University), William D. Dobson (University of Wisconsin), Emerson M. Babb (Purdue University), Paul Christ (Land-O-Lakes, Inc.), and James W. Gruebele (University of Illinois)

The federal milk marketing order program has become subject to considerable public criticism in recent years. The criticism largely has been directed at the classified pricing plan and the height of class I differentials in order regulations. An evaluation of federal order performance by Dobson indicates that price enhancement was not reflected in class I pricing during 1965–75, that class I differentials may have been higher than necessary to provide adequate supplies of Grade A milk, that federal orders have reduced market instability, and that a substantial reduction in class I differentials would generate a limited net gain to society.

A basis for evaluating proposed policy changes in the federal order program by utilizing a highly specified simulation model was presented by Babb. The simulator projects the effects of changes in pricing and pooling provisions for up to twenty quarters relative to several response variables including blend prices, milk production, returns over direct milk production costs, retail milk prices, class I sales, and milk movements. One significant feature observed from the projection of several alternative pricing-pooling arrangements was the high degree of stability in all response variables for the aggregate of federal orders, given a level of class prices, when radical changes in class and blend price structures were imposed.

Extensive discussion was directed to two areas. The assumed rate of Grade B conversion was debated in terms of its impact on the order program and the impact of order provisions on conversion. The consequences of class I price obligations for reconstituted milk on milk markets were also considered.

The Evaluation of Nonmarket Goods and Services. Reuben N. Weisz, chairman (ERS, USDA), Alan J. Randall (University of Kentucky), Shaul Ben-David (University of New Mexico), and Louise Arthur (ERS, USDA)

Just as economists are beginning to perfect an ability to conduct traditional types of benefit-cost analyses, they are being required to be equally competent in the evaluation of nonmarketable goods and services. This symposium provided an intellectual marketplace for the exchange of ideas on this issue. The following four papers were used as a point of departure.

"Evaluating Nonmarket Goods and Services: Some Conceptual Issues" answered the following questions: What can the various measurement instruments measure? How can one infer from this the value of nonmarket goods? How does this relate to the concept of consumer's surplus? "A Model of Voting Behavior for Revealing Public Sector Demands" illustrated how location theory can illuminate public preferences when the political process is used in lieu of the market place. "Epidemiology and Microeconomics" indicated that the etiology of environmental impacts on human health depends on economic as well as biological factors because the exposures and life styles of individuals are frequently matters of choice. "Development of Environmental Quality Indices: A Utility Approach" illustrated how preference values can be used to weight social indicators describing the physical impacts of a policy. A survey of public attitudes on the

coyote-predator control problem indicates that, while the individual utility functions differ greatly, differences in relative utilities of various control policies are surprisingly constant across individuals.

The New Agricultural Policy Process. Don F. Hadwiger, chairman (Iowa State University), Charles Wiggins and William P. Browne (Central Michigan University), James Guth (Furman University), and Alan S. Walter (ERS, USDA)

Three papers presented at this panel were from the Agricultural Policy Symposium, held in Washington, D.C., on 25 and 26 July 1977. Guth described the evolution of classic "subgovernment," which set federal dairy policy since the 1930s, consisting largely of the National Milk Producers Federation, the House and Senate Dairy Subcommittees, and the U.S. Department of Agriculture marketing authorities, and its fragmentation during 1950–70 with consequent greater involvement of the secretary of agriculture. He then describes the development of consumer group involvement in the 1930s and again during the past five years, focusing on the interaction of groups selective to the 1973 and 1975 farm bills and in the administrative process. He concludes that the role of consumer groups has been episodic, and they do not currently speak with one voice.

Browne and Wiggins (both political scientists) examine the current internal and external constraints upon general farm organizations and specify several conditions under which they are likely to have some political impact: when policy is handled in the traditional centers, when economic considerations predominate, when members are strongly committed to ruling objectives, and when only a few agricultural issues are salient. Walter provides an introduction to the new congressional budget process and assesses its effect upon commodity policy. It is difficult to budget because costs are often delayed for several years, and budget decisions are also greatly affected by administrative decisions, weather, and other variables. Although the direct impact of the budget process is small, Walter finds that the cost estimates provided by that process and its intended legislative constraints serve as important guidelines for congressional voting on agricultural policy.

Evaluation of Programs under Title V of the Rural Development Act of 1972. Lee M. Day, chairman (Cornell University), J. Patrick Madden (Pennsylvania State University), David L. Chewning (National Rural Center, Washington), Delworth B. Gardner (University of California, Davis), Edward O. Moe (Cooperative State Research Service, USDA), and Raymond D. Vlasin (Michigan State University)

The Rural Development Act of 1972 authorized the land grant universities of all 50 states and Puerto Rico to embark upon an experiment in rural development research and extension. The program was to receive $45 million during the first three years. The pilot program was started in fiscal year 1974. Three years later the program had received only 20% of the funds authorized. At the end of the pilot stage, the U.S. Department of Agriculture entered into a cooperative agreement with the National Rural Center (NRC), a private nonprofit organization in Washington, D.C., to conduct an external evaluation of the program. NRC contracted with Pennsylvania State University to provide the services of a principal investigator (Madden) to design and conduct the evaluation.

The Act provided only very general guidelines regarding the kinds of activities the land grant universities should perform, but it was very explicit as to several of the procedures and processes to be followed. Nonland grant institutions of higher education were also to be included; over 100 were involved, including 13 of the 16 1890 land grant colleges. Title V efforts were to be coordinated with those of various federal, state, and local agencies; widespread cooperation with agencies at all levels was reported by the states. A state rural development advisory council was to be appointed, including members from several specific kinds of agencies and institutions; all states had such a council, and a few states found it to be useful in designing their programs. The states reported a vast array of projects and outcomes. While this evaluation has not validated the impact of the state projects, enough information is presented by the states to indicate that the program has been generally successful in meeting the expectations of Congress, both in terms of the process used and the end products of rural development.

Consumer Economic Issues: Impact of Legislation and Policy. Sylvia Lane, chairperson (University of California, Davis), E. Scott Maynes, W. Keith Bryant, and Jennifer Gerner (Cornell University), Loren Geistfeld (Purdue University), Barbara S. Zoloth and Lawrence Shepard (University of California, Davis), Jean F. Bowers (Ohio State University), William C. Dunkleberg (Purdue University), and Jean Kinsey (University of Minnesota)

Two sample products, term life insurance and pocket cameras, were used in a demonstration of an economic approach to the documentation of the degree of informational imperfection of local consumer markets. The suggested corrective policy for markets found to be informationally imperfect is a sales tax supported local pro-consumer information system that would provide consumers information on price, quality and availability of products, and ratings of retailers.

Product warranties serve as market signals providing consumer information. Those parts of appliance warranties about which consumers are well informed exhibit considerable uniformity. Therefore, requiring manufacturers to provide more warranty information tends to reduce the var-

iety of warranty terms available. Consumers' ranges of choices are reduced.

Abolishing fair trade appears to have led to limited price cutting by retailers, in particular, "discount" outlets, a reduction in nonprice competition, and an increase in the frequency of business failures in fair trade states during 1976. Pricing policies of chain stores and department stores have not become more aggressive on fair trade items since repeal.

State-imposed rate ceilings on consumer credit, lessening creditor remedies, and truth in lending legislation have caused credit rationing to higher risk low-income consumers. Existing policies with respect to consumer credit imply decision makers believe there is a difference between preferences and welfare, classing consumer credit with other "sumptuary" goods.

Risk and Uncertainty for Small Farmers in the Developing Countries. Marcelino Avila, chairman (University of Missouri, Columbia), James Roumasset (East-West Center, Hawaii), Richard K. Perrin (North Carolina State University), Christina H. Gladwin (International Fertilizer Development Center, Alabama), Colin Gellatly (North Carolina State University), Luis Navarro (Tropical Agricultural Research and Training Center), and Jean-Paul Chavas and Gustavo Arcia (University of Missouri, Columbia)

In recent years, much emphasis has been given to agricultural development programs that encourage the adoption of new technologies by the small farmer. One of the most important aspects of the adoption of new agricultural methods is the risk that they represent from the view of the peasant farmers. Therefore, one of the main objectives of development plans is to seek technologies that offer a minimum risk so that acceptance can be higher. This seminar focuses on the different methodologies that are being used to measure risk and uncertainty and the difficulties that arise in the adoption of new techniques by small farmers.

Roumasset's paper deals with the identification of risk and uncertainty measurement methodologies. Perrin's presentation considers the policy implications of small farm risks in developing economies. Gladwin presents a limited model of risk taking that is hierarchical in form. Gellatly's paper concentrates on the technology adoption questions with a few comments on supply response. Navarro describes some preliminary observations concerning the manner in which small farmers have dealt with situations of risk and uncertainty. Finally, the paper prepared by Chavas and Arcia, based on the expected utility theorem, derives the optimal operating conditions for a multiproduct firm where output and output prices are uncertain and correlated. The participants are in agreement that there is great need for continued efforts in this field, particularly in reference to empirical investigation.

Structure and Performance of U.S. Food Manufacturing Industries. Bruce W. Marion, chairman (Ohio State University/University of Wisconsin), John M. Connor (ERS, USDA), Loys L. Mather (University of Kentucky/University of Wisconsin), Brian W. Peckham and John D. Culbertson (University of Wisconsin), Leon Garoyan (University of California, Davis), Marvin L. Hayenga (General Foods), and A. C. Hoffman (retired)

Connor found that asset concentration among the 100 largest food manufacturers was about the same in 1950 and 1975. "Stability coefficients" indicate the relative position of largest firms has remained very stable with no apparent trend from 1950 to 1975. Mather found the concentration of advertising among large firms in food manufacturing is high and increasing. Advertising as a percentage of sales is particularly high in industries producing highly processed foods. Preliminary results suggest that large firms cross-subsidize the advertising of brands acquired through product extension mergers.

Contrasting analyses of technological changes were reviewed by Peckham and Culbertson. Peckham conducted an innovative and detailed analysis of significant inventions in the U.S. corn-refining industry. The markets for invention were distinguished and related to product markets, the size of firms, and industry structure. In contrast, Culbertson conducted an econometric analysis of patents and research and development employment in ninety large food manufacturing companies during 1950–56. Market concentration had a consistent positive relationship to innovative activity. Relative market share and firm size were generally positively related but nonproportional in some models. Technological opportunity dummy variables were highly significant in most models.

Public Regulation of Economic Activity: Its Institutions and Impacts on the Agricultural Sector. Conrad F. Fritsch, chairman (ERS, USDA), Stan G. Daberkow and Edward V. Jesse (ERS, USDA), James D. Shaffer (Michigan State University), and Richard G. Walsh and Forrest E. Walters (Colorado State University)

Research measuring the impact and effectiveness of public regulation of economic activity does not lend itself easily to traditional economic inquiry. While costs may be measured, given a set of normative assumptions, benefits received are often diffused and poorly identified. Costs associated with regulation of given products have been computed. For example, direct and indirect costs of about 8¢ are incurred per pound of ground beef. Yet cost measurement does not necessarily identify the significant changes in choices available to different economic actors. Regulations restrict the choices of some persons, but they expand those of others. In the same way market processes also expand choices for some persons while restricting them for others.

A loss of faith in the ability of the market system to provide acceptable degree of product quality and safety is seen by some as the reason for an increase in the activity of regulatory agencies since 1970. Regulation of economic activity, however, is not the only means of attaining socially desirable outcomes. A desired goal of reduced workplace accidents in the agricultural sector, for example, is currently being pursued through market incentives via variable rate insurance schemes, direct regulations, resort to judicial processes, and voluntary action programs. To adequately deal with the economics of influence, information, and bureaucracy associated with the regulatory process, economists need to do considerable conceptual and empirical work and the scope of the discipline will need to be expanded.

Applications of Stochastic Control to Agricultural Policy and Decision Making. Richard E. Howitt, chairman (University of California, Davis), Gordon C. Rausser (Harvard University), and Karl A. Fox (Iowa State University)

An agricultural policy analyst is faced with problems such as structural change, parameter variation, and the formation of expectations that complicate the assessment of alternative policies. Policy analysis is thus an ongoing process utilizing econometrics, optimization systems, simulation, and data base improvement. One framework that consistently integrates the foregoing is stochastic control theory.

A classification of stochastic control approaches based on the information structure used was advanced. The simplest structure is the certainty-equivalent, open loop specification initially proposed by Theil and Simon, while the most complex structure is specified in the adaptive closed loop solution of Tse, Bar-Shalom, and others using active learning. A simple analytical example illustrates the value of active learning, and approximate solution techniques for the adaptive stochastic control problem are compared for solution complexity and policy decision advantage.

The operational advantages of the simpler open loop feedback control specification are considered for the linear-quadratic-Gaussian and nonlinear gradient solution procedures. The practicality of these methods is shown with a nine-state simultaneous equation model, and some caveats concerning objective function specification and inequality constraints are offered. The consistency of optimal policies derived by stochastic control with the theory of economic policy based on Tinbergen's seminal work is shown. An inconclusive verdict was offered on the current policy advantages of the more complex adaptive stochastic specification, while the practical utility of the open loop feedback solutions under the more restrictive information structure was affirmed.

Report of Workshop on Agr Data: Improvement of Conc Gaylord Worden, chairman (O and Budget), James P. Houck nesota), and Clark Edwards (I

A workshop was held in May 1 cepts and operation of severa tems. The workshop consisted data suppliers and data users and recommendations made each topic. Study teams then ports by including changes rec shop participants.

The purpose of reporting on annual meeting of AAEA was audience to the topics studied sions and recommendations of topics on which reports were p teams were a history of agricu agricultural prices and price r the capacity of the agricultural data for indicators of well-bein in farming, definition and meas ployment, and employment da ment research and policy.

Emerging Issues of Minorities Labor Markets. Harland I. Pad gon State University), Emiel W. Houston), Christine R. Heator and Rufugio I. Rochin (Univ Davis)

Rural labor markets are histor presence of migrant field w Mexico, and, more recently, force participation rate of fe Heaton and Martin indicates th to predict labor force participa ban, single females do not exp pation rates of rural women an cal models are necessary to ass behavior, especially the differe and single women. Migrant w by Owens to determine the ext workers experience pesticide-r chemical analysis of cholineste exposure to pesticides indicate East Coast migrant stream are variety and high dosage of p which are lethal. A study by Ro can workers in agriculture iden plain the process of illegal imm nomic factors manifested in the sis are important for explainin Mexico, immigration laws hav and changed to control the inflo ers in tune to the domestic req labor. Another explanation g influx from Mexico is that larg workers willing to work in a exhausted because of a combin

as the war on poverty and the liberalization of welfare and food stamp programs, giving rise to a situation in which employers rely on the seasonal workers from Mexico to fill a domestic "labor vacuum." A common theme noted by Padfield is the extent to which women and minorities have been subjected to adverse conditions in rural labor markets without the full benefits of research and public policy interventions.

Relationship of Extension Economists to the AAEA. Charles Rust, chairman (Montana State University), Robert L. Christensen (University of Massachusetts), Norbert A. Dorow (North Dakota State University), William W. Wood (University of California, Riverside), A. Gene Nelson (Oregon State University), Sharon Q. Hoobler (Extension Service, Washington, D.C.), Richard W. Schermerhorn (University of Idaho), and Fred A. Mangum, Jr. (North Carolina State University)

A survey of extension economists sought suggestions and criticisms. Those surveyed felt that annual meetings offer little to extension economists. They repeatedly suggested that there should be more orientation toward applied work and micro level analyses. A need for sessions at the annual meeting for extension economists was also a popular request. A large majority felt that the *Journal* has limited value to them; a small minority indicated that the *Journal* publishes a mix of articles that is acceptable. Opinion was divided on the performance of the AAEA in promotion of professional development and excellence. However, 80% felt the level of services to extension professionals was less than that offered to research and teaching.

Not only do extension economists need the AAEA but the AAEA, representing the profession in general, needs extension economists. The responsibility for drawing extension economists into a closer working relationship with the AAEA needs to be shared jointly. Extension economists need the AAEA for professional enhancement, influence on research directions, and efficiency. One area of continuing need is a forum for informed discussion and debate on broad and current issues related to agriculture. In general, the AAEA does not meet the most commonly expressed needs of the extension economists.

The AAEA is a professional association of agricultural economists. Its members are engaged in 27 work activity areas including extension. There are 15 fields of specialization divided into 102 subject matter areas. The Board's position is that it should provide a form for all elements of the Association to do whatever a group of members feels is important. There are two constraints: funds to conduct programs and some assurance that the activity proposed will reflect favorably on the total Association. The records show that where extension economists have taken the initiative we have achieved our objectives. The degree of participation by extension economists will largely determine what share of the support it obtains from the AAEA.

Contributed Papers

Food and Agricultural Policy (Martin K. Christiansen, University of Minnesota, Chairman)

"Participation in the Food Stamp Program and Implications Concerning the Need for Outreach Programs." W. Keith Scearce and Robert B. Jensen (Virginia Polytechnic Institute and State University)
This paper focuses on the likely effectiveness of outreach efforts for the USDA Food Stamp Program. A discriminant function is developed that ranks characteristics affecting participation or nonparticipation by eligible families. These results raise questions as to whether any outreach effort will improve the participation rates among eligible families.

"Comparison of Federal Subsidies to Cotton Producers." George A. Shumaker and Ronald M. North (University of Georgia)
Some American cotton producers realize two forms of federal subsidies: the USDA Cotton Program payments and subsidies brought about by the methods utilized for the repayment to the Bureau of Reclamation for irrigation water resource projects. The two subsidy forms were analyzed and compared with respect to inter- and intraregional incidence. Crop years 1971 and 1974 were selected for intensive investigation.

"Peanut Market Structure: Analysis of Its Influence upon Peanut Policy Trade-Offs." James N. Trapp (Oklahoma State University)
Analysis of the potential to discriminate between the edible and nonedible peanut markets indicates that opportunities to reduce treasury costs exist through peanut programs that conduct market discrimination. Consideration of market discrimination capabilities in administration of the current peanut program could reduce treasury costs while raising farm income.

"An Analysis of the Effects of Government Policies on the United States Oilseeds, Oils, and Oil Products Industry Using a Monthly Econometric Model." R. McFall Lamm, Jr. (ERS, USDA, Virginia Polytechnic Institute and State University)
The effects of government policies on the domestic vegetable oilseeds, oils, and oil products industry are evaluated in this paper by analytically deriving impact multipliers and by performing deterministic simulation experiments. Significant decreases in some industry prices are indicated if government controls are removed from the industry.

"Adjusting Price Supports: Comparison of Alternative Methods." Jerry A. Sharples (ERS, USDA, Purdue University)
Five price support adjustment methods are discussed: parity, prices paid index modified by yield changes, cost of production, historical price trends, and discretionary authority. After a brief description, they are compared relative to a theoretical ideal, on an objectivity scale, on ease of measurement, and over a historical period.

"Implications of Uncertainty in Yields and Exports." Theodore F. Moriak (Office of Management and Finance, USDA)
A prototype procedure is presented for developing subjective, probabilistic evaluations for future uncertainties about commodity yield and export expectations. The subjective uncertainty information is incorporated into a large multicommodity systems model in order to estimate future commodity price uncertainties that are useful for public policy and program decisions in agriculture.

Transportation (C. Phillip Baumel, Iowa State University, Chairman)

"Modeling the Economics of Rail Terminal Operations in Grain Transportation: A Brazilian Case Study." Charles L. Wright, Richard L. Meyer, and Francis E. Walker (Ohio State University)
Transportation costs are decomposed into line-haul costs and terminal costs. Physical handling efficiency at terminals decreases overall transportation costs and augments service capacity. A capacitated network model is used to apply this general concept to rail transportation bottlenecks on a Brazilian export corridor.

"The Economic Impact of Alternative Policies on the Illinois Grain Marketing System." James M. Harris (University of Illinois), E. Dean Baldwin (Ohio State University), Lowell D. Hill (University of Illinois), and C. Thomas Worley (Ohio State University)
Policy makers confront a complex world and have many alternatives. An economic and analytical framework was employed to evaluate the effects of alternative policy options on the Illinois grain marketing structure and flow patterns. Firms, transport modes, firm services, and flows among intrastate regions and firms are endogenously determined.

"A Regional Perspective of Agriculturally Exempt Motor Carriers in the United States: Problems and Characteristics." Robert K. Stump (Cominco American, Inc.) and Kenneth L. Casavant (Washington State University)
This paper analyzes the problems facing truckers as well as their operating characteristics in relation to regional location. Regionality has a strong impact

on trucker problems and operating characteristics. Commodity specialization, which is closely associated to region, might be a determinant of many problems and operating characteristics experienced by these truckers. Results indicated that policies based on aggregation of the national trucking industry should be instituted with some reservations.

"Research and Data Needed to Improve Transportation Mobility of Rural People in the West." Jerome J. Hammond (FDD, ERS, USDA) and Erhardt O. Rupprecht (NEAD, ERS, USDA)
Western rural residents depend upon the automobile for their transportation needs. Coupled with the lack of transportation alternatives, this can have serious consequences for the transportation disadvantaged. Research and data are needed to determine demand, cost, and feasibility of alternate means of providing mobility to rural people.

"A Modified Lockset Approach to Routing for Backhaul Effectiveness." Lynn W. Robbins (University of Kentucky)
Transportation micromodels' inadequate adaptability to specific routing problems—backhaul effectiveness, irregular dealer demand, and partial loads—are evaluated. A specific lockset modification is presented with examples from its application. The related discovery of a potential theoretical breakthrough in transportation research is outlined along with suggestions for capturing that potential.

"Alternatives to Railroad Line Abandonment." Marc A. Johnson (Oklahoma State University)
Railroad preservation projects are composed of four functional parts: ownership, right-of-way rehabilitation, right-of-way maintenance, and rail service operation. These functions may be performed by one agency or distributed among agencies in a variety of ways. Rail preservation alternatives are of three types: short-line railroading, rehabilitation assistance, and subsidization. Each is feasible under different traffic conditions.

Economic Issues in Developing Countries (J. C. Andersen, Utah State University, Chairman)

"Packages of Practices: A Step at a Time with Cluster?" Charles K. Mann (Middle East Technical University, Turkey)
Despite increased use of modern technology, few Turkish wheat farmers have adopted the complete recommended package of practices. Reconsidering the package as clusters of practices adopted in an agronomically and economically logical sequence provides a better explanation of farmer behavior and a guide for useful agronomic experimentation and economic analysis.

"A Socio-Economic Analysis of Technology Adoption in an African Livestock Industry." Gregory M. Sullivan, Donald E. Farris, M. J. Yetley, and W. J. Njukia (Texas A&M University)
The study examines the Tanzanian livestock industry to explain low levels of improved management and commercial sales. Level of technology adoption and two perceived economic values by producers are estimated in 792 herds. Communal grazing and depressed government regulated prices of cattle are determined as factors causing low levels of technology adoption.

"Coca Substitution in Bolivian Agriculture: Political Economy or Expediency?" Morris D. Whitaker (Utah State University) and Clovis Villegas (Bolivian Ministry of Rural Affairs and Agriculture)
Bolivia, with concessional U.S. aid, is implementing programs for substituting other crops for E. coca, from which cocaine is derived. Survey data are analyzed to determine the profitability of alternative crops. Results indicate coca is the most profitable and imply low returns to public investment in crop substitution programs.

"Rational and Beneficial Use: Chile's Criterion for Irrigation Water Reallocation." Loren L. Parks (Oklahoma State University) and David E. Hansen (University of California, Davis)
The 1967 Water Code requires equalization of water rights per hectare in a "homogeneous farming area." Analysis of a typical region using representative farm linear programming models indicates that equalization would result in regressive income redistribution, whereas the optimum economic reallocation would result in progressive income redistribution. Aggregate income gains in either case would not exceed 5%.

"An Analysis of Capital Requirements of the UNCTAD Integrated Program for Commodities." John W. Murray (NEAD, ERS, USDA) and L. Jay Atkinson (FDD, ERS, USDA)
Developing countries have proposed a common fund for an "Integrated Programme for Commodities" to finance several international agreements. Ordinary least squares is used to establish unit value and export earnings trends. Estimates of capital requirements are calculated for compensatory financing and export earnings and unit value stabilization using buffer stocks.

"The Economics of Sharecropping in Northeast Brazil." Lee W. Bettis, Richard L. Meyer, and Francis E. Walker (Ohio State University)
Incentives exist for landowners to employ sharecroppers in Northeast Brazil. Four components of a sharecropping contract were parameterized for measuring the sensitivity of landowner income, number of sharecroppers employed, and enterprise mixes, revealing unexpected relationships. These results are important to policy makers interested in regulating sharecropper contracts.

Energy (F. Larry Leistritz, North Dakota State University, Chairman)

"Energy Price Changes: The Impact upon Farm Production Methods and Energy Consumption." Michael Hammig, David Holland, and William Pietsch (Washington State University)
This inquiry examines the sensitivity of agricultural production techniques to increases in selected input prices. A linear programming model was developed incorporating production practices under a wide range of capital, labor, and energy intensities. Findings indicated relatively inelastic input demand functions and not much potential for energy saving in response to energy price increases.

"Waste Heat Utilization in Agriculture: Economic Feasibility and Institutional Alternatives." Ronald L. Meekhof (CED, ERS, USDA)
Recycling of energy resources is an issue of national concern. The economic feasibility of utilizing thermal effluent from power plants in a system of agricultural and aquacultural use is evaluated. Such a system is an economically feasible alternative to conventional methods of dissipating waste heat under selected management and acquisition options.

"Adjustments in a Farm Business in Response to an Energy Crisis." Robert O. Burton (Purdue University) and Ralph G. Kline (Virginia Polytechnic Institute and State University)
Adjustments to an energy crisis are investigated from a farm manager's point of view. Using linear programming models, the effects on returns, cropping systems, and energy use for Grade A dairy farms with till and no-till corn systems and solid and liquid manure systems are determined.

"Breakeven Natural Gas Prices for Irrigation: Texas High Plains." Daniel C. Hardin (Texas Water Resources Institute) and Ronald D. Lacewell (Texas A&M University)
The effect of natural gas price on irrigated agriculture is of major concern in many regions. This study estimates for the High Plains of Texas producers' ability to pay for natural gas by land tenure arrangements and irrigation well characteristics and discusses the implications for crop adjustments and land values.

"Impact of Energy Cost of Irrigated Production, High Plains of Texas." John L. Shipley (Texas A&M University) and D. W. Goss (ARS, USDA, Texas A&M University)
Irrigation well cost data and value of water in crop production were used to estimate price of electricity to equate net returns from irrigated and dryland production. Rising energy prices without corresponding rises in product prices could result in energy, rather than water, being the limiting factor in High Plains irrigation.

Water and Marine Economics (Melvin D. Skold, ERS, USDA, Colorado State University, Chairman)

"A Method for Estimating Benefits to Fishermen of a Channel Dredging Project." W. Davis Folsom (Clemson University)
The benefits to fishermen of a channel dredging project are in the form of increased fishing time and decreased hull damage. A more reliable estimate of the benefits can be derived when allowances are made for the boat draft and number of days per fishing trip.

"A Model for Determining Optimal Multi-National Exploitation of a Marine Fishery." Marilyn A. Altobello (University of Arizona) and Jon M. Conrad (University of Massachusetts)
The Fishery Conservation and Management Act of 1976 provides the institutional framework needed for managing fishery resources in U.S. coastal waters. This paper outlines a discrete-time bioeconomic model that may be employed by a central decision maker in managing a single-species fishery characterized by multinational exploitation.

"Projected Impact of Lower Granite Dam and Suggested Waterway User Fees on Pacific Northwest Wheat Movement." Robert Thayer and Kenneth Casavant (Washington State University)
This paper reports on a regional study of the impact of improvements in water navigation and waterway user charges on wheat movements. A transportation model minimizing transportation costs served as the analytical model. As expected, shippers and geographical areas in close proximity to the river gained from improved navigation. Not so expected, the strong competitive reaction of the railroads allowed distant areas and producers to gain from improved waterways. User fee charges had impacts similar to the lower water-induced rail rates.

"Economic Interdependencies in Fisheries: Empirical Evidence and Management Implication." Ivar Strand and Aldo Matteucci (University of Maryland)
The federal government is charged with determining a "socially optimal" flow of fisheries resources. Economic interdependencies between fisheries are empirically examined for crabs and oysters to substantiate the argument that joint management plans are necessary to assure "socially optimal" flow.

"Impact of the Elimination of Water Rights on Land Rent and the Distribution of U.S. Agricultural Production in 2000." W. Arden Colette (University of Florida) and Earl O. Heady (Iowa State University)
Alternative solutions of a national linear programming model indicate that *(a)* at normal demand levels total returns decrease but at high levels of export total land rent increases, *(b)* more dryland is used and returns per acre are higher, *(c)* returns per irrigated acre decrease, and *(d)* the North Central region becomes more dominant both in proportion of cropland and total returns.

Human Resource Development (A. Frank Bordeaux, Jr., University of Kentucky, Chairman)

"Human Capital and Labor Turnover in Manufacturing Industries: The Case of an Economically Depressed Region in Southeast Ohio." Emmanuel T. Acquah (Virginia State College) and Leroy J. Hushak (Ohio State University)
The study examines labor productivity and quit and layoff behavior of manufacturing production workers. Manufacturing firms employ relatively unskilled workers and make relatively small investments in specific human capital. To generate increasing income levels over time, industrial development efforts need to focus more on employment opportunities that require increasing skills.

"Factors Influencing Physician Location Decisions in Oklahoma." Marcia Huddleston Salkin and Michael S. Salkin (Oklahoma State University)
Many rural communities in Oklahoma are without adequate physician service because doctors locate in more urban communities. Here, we attempt to explain the physician location decision process by testing several hypotheses. The role of personal characteristics of physicians and community characteristics are examined. Conclusions include ways in which rural communities can attract doctors.

"An Income Determination Model with Implications for Occupational Mobility in a Rural Labor Force." Joe B. Stevens (Oregon State University) and David E. Ervin (University of Missouri)
"Excessive" job changing by workers is perceived as irrational behavior by employers in Oregon's wood products industry. A hypothesis of equimarginal returns to firm-specific and general work experience is tested with a partitioned income determination model. The revealed incentive structure encourages frequent job changing.

"The Influence of Psychic Costs on Human Resource Allocation." Brady J. Deaton (University of Tennessee), Larry C. Morgan (Texas A&M University), and Kurt R. Anschel (University of Kentucky)
Eastern Kentucky migrants in two urban centers were studied to determine the income levels required to induce a return to their home region. The average income specified was $1,777 below 1971 earned family income and close to the actual 1971 average earnings in eastern Kentucky. Roughly 50% of the variation in the income differential was explained by regression analysis.

"Household Migration into a Small Rural Southern Area." Leon B. Perkinson (ERS, USDA, North Carolina State University)
Households migrating into a small rural area had higher average incomes than native households but had heads that were younger and more educated. Multiple regression results indicated migrant households had over 15% less income in 1974 than native households with similar characteristics.

Environmental Quality (Richard W. Schermerhorn, University of Idaho, Chairman)

"Benefits and Costs of Surface Mine Reclamation in Central Appalachia: A Case Study." Alan Randall, Angelos Pagoulatos, Orlen Grunewald, and Sue Johnson (University of Kentucky)
The benefits of reclamation under current Kentucky regulations exceed reclamation; the incremental benefits of reclamation, under the currently introduced federal bill, are positive and under certain assumptions exceed costs. Even assuming application of best available reclamation technologies in the study region, surface coal mining generates residual social costs.

"Impact of Construction Subsidies on Optimal Crop Mix for Land Treatment of Municipal Wastewater." C. Edwin Young (NRED, ERS, USDA), Edward B. Bradley (University of Wyoming), and Donald J. Epp (Pennsylvania State University)
Least-cost solutions for land treatment of municipal wastewater are estimated for three levels of capital cost subsidy: no subsidy, 75%, and 85%. Irrigation of reed canary grass is superior to alfalfa, corn, forests, and natural vegetation (weeds). If the local municipality minimizes its costs while receiving subsidies, inefficiencies result.

"Application of a Multi-Goal Linear Programming Model to Measure Trade-Offs Between Cost and Environmental Variables in Agriculture." Gary Vocke, Earl O. Heady, and Orhan Saygideger (Iowa State University)
This study uses a large-scale multigoal interregional linear programming model to derive trade-off information between the goals of economic efficiency and soil conservation for U.S. agriculture. This information concerning resource use and implied income distribution effects can be used in formulating national land use policies for agriculture.

"Internalizing Externalities of Phosphorus Discharges from Crop Production to Surface Water: Effluent Taxes versus Uniform Reductions." George L. Casler (Cornell University) and James J. Jacobs (University of Wyoming)
An empirical test confirms the hypothesis that effluent taxes are economically more efficient than uniform reduction or uniform treatment. In this situation, costs to dischargers (farmers) are greater for the tax policy than for the uniform reduction policy, a point overlooked by many advocates of effluent taxes.

"Optimal Extraction with Stochastic Externalities: The Case of Offshore Petroleum." Jon M. Conrad (University of Massachusetts)

A model of offshore petroleum production is constructed where the rate of extraction positively affects the distribution of spills. An optimal rate of extraction is derived that takes into account the conditional distribution on spill damages, and an optimal liability rule is identified. An adaptive control formulation is outlined.

Management of Productive Inputs (T. Kelley White, Jr., Purdue University, Chairman)

"Break-Even Land Prices: A Normative Analysis of Their Determinants." Robert P. Zentner and Kurt K. Klein (Agriculture Canada)
Break-even land prices are derived for various factors affecting disposable net income per acre. The analysis includes a frequently overlooked consideration—the repayment capacity of the existing stock of assets. In addition, the effects of alternative cropping patterns with varying degrees of riskiness in net income are determined.

"An Economic Theory of Production, Investment, and Disinvestment." Alan E. Baquet (Michigan State University)
Durable inputs in production have long been an imbroglio. A theoretical model linking production, investment, and disinvestment is presented. Both the optimal flow of services and the economic life of the durable are determined internally. This formulation allows for consideration of both stock and flow quantities in the production process.

"Impact of Wage Rates on Optimal Machinery Complements." Darrel D. Kletke (Oklahoma State University) and Steven C. Griffin (Iowa State University)
The complex problem of choosing optimum machinery complements is approached using mixed integer linear programming. Wage rates and farm size are varied with the resulting optimal complements compared. Higher wage rates cause capital to be substituted for labor, and machinery costs per acre decrease as farm size is increased.

"Labor Management Time Allocations in Economies of Farm Size Studies." Roger G. Johnson and Steven Hvinden (North Dakota State University)
Data from North Dakota farmers were used to develop regression equations estimating seasonal farm operator labor and management time use by farm size. Management time had a large fixed component and increased linearly with farm size. Labor supervision time increased at an increasing rate with amount of labor supervised.

"Farm Real Estate Disinvestment Strategies." D. Lynn Forster and Richard D. Duvick (Ohio State University)
Seller financing of real estate sales is a predominant source of farm real estate credit. Annual consumption and savings of sellers are modeled over time under alternative selling strategies. Rules of thumb are developed for optimum lengths of sales under alternative seller financial characteristics.

"The Use of Shadow Prices in Determining Marginal Values." Fred J. Stewart and Richard A. Greenhalgh (ERS, USDA, University of Florida)
The problem of evaluating the need for land development projects for agricultural uses is addressed in a marginal analysis utilizing shadow prices. A linear programming framework was used with physical and historical characteristics of the land resource being defined and constrained. A procedure for assigning marginal values to an entire package of land resource characteristics is presented.

Demand and Supply Analysis (Richard Green, University of California, Davis, Chairman)

"Price Stability and Carry-Over Levels of Tart Cherries." Stanley R. Thompson and Leslie J. Butler (Michigan State University)
An econometric model is developed that is used in conjunction with a dynamic programming model to examine the unstable nature of prices in the cherry industry. The model delineates some areas of marketing strategy that may enable the cherry industry to deal more effectively with uncertain market conditions.

"An Econometric Analysis of the Supply Response for North Carolina Field Crops." Stanley M. Fletcher and Colin Gellatly (North Carolina State University)
This paper empirically evaluates the importance of risk in decision making. The Just model is applied in the analysis of North Carolina field crop supply response. Results indicate that effects of stabilization, possibly through government programs, might have partially offset the acreage-reducing effects of voluntary acreage restriction.

"Risk in Supply: The Case of U.S. Pinto Beans." Timothy J. Ryan (University of Minnesota)
Some simple risk specifications were estimated for pinto beans during 1953–75. The two preferred equations, one containing a weighted standard deviation of prices, the other a weighted coefficient of variation of prices, were superior to the no-risk variable specification. Policy initiatives to reduce price fluctuations need to incorporate the effects of supply.

"U.S. Demand for Fish Meal." Joseph Havlicek, Jr. (Virginia Polytechnic Institute and State University) and Faustino Ccama (La Universidad Nacional Technica del Altiplano, Peru)
Fish meal quantity demanded is inelastic with respect to its own price and that of soybean meal but elastic with respect to chick and lagged broiler

prices. Quantity demanded adjusted fairly rapidly to economic stimuli and in the long run is elastic except with respect to the price of corn.

"The Economics of Coupons." Ronald W. Ward (University of Florida) and James E. Davis (Bullock County Bank of Georgia)
Coupons are widely used in the promotion of food products. Theoretically, they should stimulate consumer responses through the informational effect as well as with the direct price discount effect associated with redemption. A pooled cross-section time-series model is developed to show both effects of coupons on the consumption of frozen orange juice.

Marketing (James A. Niles, University of Florida, Chairman)

"Impact of Alternative Class I Pricing Systems on the Location and Structure of the U.S. Dairy Industry." Richard F. Fallert, Harold W. Lough, and David E. Cummins (CED, ERS, USDA)
The projected regional aggregate impacts on the dairy industry of continued classified pricing under the federal milk marketing order program and under elimination of federal milk orders are evaluated. The effects are measured on milk production, fluid consumption, and price, with special emphasis on industry location and structure.

"The Average-Marginal Conflict in Milk Pricing." Floyd A. Lasley (CED, ERS, USDA)
Pooling and pricing under federal milk marketing orders have helped create a more stable marketing situation by translating marginal incentives and risks into averages. However, this paper considers how current instabilities stem from lack of satisfactory retranslation of average needs, costs, and incentives back into marginal response.

"A Review of the Experimental Effects of Increased Price Information on the Performance of Canadian Retail Food Stores in the 1970s." D. G. Devine (University of Saskatchewan)
Recent Canadian studies on measuring the impact of improving retail food price information reveal that information is a valuable economic resource that may be used as a tool in modifying retail conduct and performance. The publication of comparative retail food prices resulted in lower price spreads between stores, lower average city prices, and increased consumer satisfaction with the market. Retail price information seems to have many of the characteristics of a public good.

"Advanced Estimates as Predictors of Receipts at Six Markets." John R. Franzmann (Oklahoma State University)
The advanced estimates of livestock receipts is of potential value to those who market and/or hedge livestock. Usefulness is dependent on the accuracy of the estimates. This paper examines the accuracy of the six market advanced estimates and their usefulness in making marketing or hedging decisions.

"Rational Price Formation in the Fed Cattle Futures Market." Stephen E. Miller and David E. Kenyon (Virginia Polytechnic Institute and State University)
The failure of fed cattle futures prices to forecast fed cattle cash prices is traced to the presence of rational price formation in that futures market. Implications for cyclic fed cattle production and cash price variability are drawn from the presence of rational price formation in that futures market.

"A Framework for Evaluating the Economic Impact of Classified Pricing of Milk." Boyd M. Buxton (ERS, USDA, University of Minnesota)
Alternative classified pricing policies for milk are evaluated using a nine-region model of the U.S. dairy industry. Higher (lower) class I differentials generally are of advantage (disadvantage) to producers in the Northeast, South, and West regions and of disadvantage (advantage) to producers in the Upper Midwest, especially Minnesota and Wisconsin.

International Trade (Thomas S. Clevenger, New Mexico State University, Chairman)

"Effects of Currency Adjustments Given Free Trade and Trade Restrictions." Maury E. Bredahl (ERS, USDA, University of Minnesota) and Abner W. Womack (CED, ERS, USDA)
Comparative static models are developed that measure changes in equilibrium prices and quantities traded due to an exchange rate change. Effects are determined for a free trade model and compared with that incorporating trade restrictions similar to those employed by the European Community. Quantity changes exceed price changes. Exchange rate effects are greater if trade is restricted.

"Factor Intensity of U.S. Agricultural Trade." Gerald Schluter and Gene K. Lee (NEAD, ERS, USDA)
The labor and capital intensities of U.S. agricultural trade during 1974 are examined through an input-output model. The empirical results indicate U.S. agricultural exports tend to be more capital intensive, while agricultural imports are more labor intensive, a result counter to Leontief's Paradox.

"The Distributional Impact of Trade Liberalization in the U.S. Grain/Livestock Sector." David Blandford (Cornell University)
Regional estimates of gains and losses by economic class of farm are derived for the base year 1970. Theil's inequality index is used to assess distributional impact. Although free trade leads to greater interregional inequality, intraregional inequality declines. The effect is a decline in total inequality.

"The Impact of Imports of Manufactured Milk Products on the U.S. Dairy Industry." Andrew M. Novakovic and Robert L. Thompson (Purdue University)
The time paths of adjustment of consumption, production, and price of specific dairy products and raw milk are estimated under three alternative levels of manufactured product imports. Much larger than historically "normal" import levels are required to bring about a substantial impact upon the dairy industry in the longer run.

"Exchange Rates in International Commodity Models: The Common Currency Question Revisited." William H. Meyers (University of Minnesota)
This paper clarifies the difference between estimating supply and demand equations for individual countries in national currencies or converting to common currency prior to estimation. The appropriate procedure for a pooled cross-country time-series estimation model depends upon the cross-sectional constraints and whether nominal or real values are used.

"An Econometric Model of World Wheat Trade with Emphasis on U.S. Exports." Donald O. Mitchell (Michigan State University)
An econometric model of the international wheat market is developed and evaluated. The model attempts to capture the essential elements of the demand for U.S. wheat exports by explaining the linkages between wheat importing and exporting regions. A market share approach is used to link the exports of wheat from the United States to the world market.

Production Analysis (Chauncey T. K. Ching, University of Nevada, Chairman)

"Technological Change and Labor's Relative Share: The Mechanization of U.S. Cotton Production." Marshall A. Martin (Purdue University) and Joseph Havlicek, Jr. (Virginia Polytechnic Institute and State University)
Labor's relative share is determined by the elasticity of factor substitution and the bias of technological change. U.S. cotton production was rapidly mechanized after World War II. The adoption of labor-saving technology, given an elasticity of factor substitution greater than one, resulted in a decline in cotton labor's relative share.

"Using Cobb-Douglas Functions in Nonlinear Programming: A Regional Sector Model." David L. Watt (NEAD, ERS, USDA)
Combining Cobb-Douglas production functions and a programming algorithm into a single framework provides an effective tool to determine optimal input levels and commodity production levels. A regional application of the model involving an eight-year tracking period is reviewed. Profit maximization is enforced by equating the marginal value products with input prices. Input and output prices are represented by continuous functions.

"The Demand for Farm Tractors in the United States." Dean W. Hughes and John B. Penson, Jr. (Texas A&M University)
Several shortcomings are noted in previous studies of the aggregate demand for farm tractors, including the measurement of the cost of capital and capacity depreciation. Empirical results presented in this study show that net investment regressions based upon the USDA's capital series are inferior to those based upon engineering data.

"Research Expenditures, Education, Weather Variables, and the Agricultural Production Function." Bernard J. Morzuch (University of Wisconsin–Madison) and Stanley R. Johnson (University of Missouri–Columbia)
Using the production function concept, Griliches attributed changes in U.S. agricultural output to time-related education and research quality indices. This procedure was duplicated using Missouri farm survey data, allowing for measured weather variables. Ordinary least squares with dummy variables and an error components model were the estimation procedures used.

"Development of an Innovation Possibility Frontier for Purposes of Research Planning and Evaluation." Kurt K. Klein (Agriculture Canada) and Earl W. Kehrberg (Purdue University)
Agricultural research activities can be planned and evaluated on the basis of an innovation possibility frontier. Procedures for estimating such a frontier (to be employed in a normative context) are developed. Its uses for screening projects and for sensitivity analyses are emphasized.

"A Study of the Interaction of Weather with Alternative Environmental Policies." Won W. Koo (Montana State University), William G. Boggess and Earl O. Heady (Iowa State University)
This study evaluates the relationship between various agricultural environmental policies and weather variations. The indices for relative weather variability in each state are estimated by grafted polynomials and are incorporated into the changes in production patterns under alternative environmental policies to evaluate the impacts of the policies on the variability in production due to weather.

Regional Analysis (Martin Redfern, University of Arkansas, Chairman)

"Construction of a Multiregional Input-Output Model for the Pacific Northwest from Secondary Data." John R. Wilkins (ERS, USDA, Oregon State University)
Existing state input-output models for Oregon,

Washington, and Idaho were updated to 1972 and aggregated to a common sector pattern. Import and export submatrices were developed using a national multiregional I-O model and a theoretical technique. The matrix was pieced together and balanced by adjusting individual matrix elements. Preliminary model application was on northwestern U.S. energy and irrigation alternatives.

"A Comparison of Agricultural Net Returns and Regional Household Receipts Under Alternative Strategies of Groundwater Depletion." James E. Casey (Oklahoma State University), Lonnie L. Jones and Ronald D. Lacewell (Texas A&M University)
Northern Texas and western Oklahoma agricultural producers face the prospect of inadequate groundwater supplies to sustain future agricultural production. Given decreasing water levels, the extraction costs or physical capacity of the wells will prohibit bringing additional acres under irrigation and force reductions in the number of irrigated acres. A regional model for evaluating alternative strategies of utilizing the existing groundwater supplies is presented.

"An Analysis of Income Distribution in the Northeast Using the Gamma Density." Richard N. Boisvert (Cornell University)
Family income distribution for 1970 in the Northeast is approximated by a gamma distribution. From regression results, increases in labor productivity and education were effective in raising average incomes. Reducing income inequality or the numbers of families with low incomes requires educational training and employment programs aimed directly at disadvantaged groups.

"Elasticities: Better Policy Statistics from Interindustry Studies." Harry W. Ayer (ERS, USDA, University of Arizona) and James Baskett (Loyola University)
It is argued that multipliers from interindustry studies are easily misinterpreted. Elasticities are developed and presented as a more relevant policy statistic. A current example of the relative advantage of elasticities is given. Elasticities better reflect the potential for needed sector growth and use more readily available and comprehended data.

"Modeling Local Fiscal Behavior: The Response of Oregon County Governments to Mental Health Grants." Bruce A. Weber and John F. Savage (Oregon State University)
Regression results from a theoretically based model of county spending suggest (*a*) mental health grants do stimulate new county mental health spending but not to the full extent implied by matching ratios and (*b*) under current conditions, marginal changes in matching ratios may not be an effective policy tool to stimulate county spending.

"The Economic Impact of Manufacturing Plants in a Five-County Region in Southwest Ohio." Leroy J. Hushak and Alan Osman (Ohio State University)
This study examines the net benefits generated by manufacturing plants on local, county, and regional communities. Use of incremental income instead of consumption to measure primary benefits results in a significant increase in net benefits. Significant increases of internalized benefits occur from local to county and county to regional levels.

Land Use Policy Analysis (Jack D. Edwards, Bureau of Land Management, U.S. Department of Interior, Chairman)

"The Model Land Development Code—Economic Impacts of Area of Critical State Concern Designation." Clyde Kiker and Gary D. Lynne (University of Florida)
A large area in Florida was designated an "Area of Critical State Concern" to protect water resources. Economic analysis of the region indicated water was not a scarce resource and the area could sustain large transfers of water to other areas and still support major increases in land use. The regulations, based on physical criteria, curb economic uses. The code, while having many desirable features, could lead to economic efficiency and distributive problems.

"Location of Agricultural Districts Relative to Urban Places in New York." Nelson L. Bills (ERS, USDA, Cornell University)
Forty-two states allow farmland to be assessed at use rather than market value. New York has combined preferential assessment with the concept of agricultural districts. Several districts are located within commuting zones around central cities, but few are adjacent to or within 10 miles of an urban place.

"Land Use Policy and Agricultural Land." Charles A. Sargent (Purdue University)
Current agricultural land use issues are analyzed in terms of urban development demands and agricultural needs. Loss of total farm land acreage, efficiency of land use, externalities, public and private costs, and urban development quality problems are examined. Four kinds of policy options for community growth management are evaluated.

"Land Use Change Detection from Satellite Imagery." John T. Cygul, James E. Hariston, Wesley N. Musser, and Fred C. White (University of Georgia)
This study focuses on the practical utility of using satellite imagery to determine agricultural land use changes in Georgia. Procedures used in analyzing LANDSAT data and associated cost effectiveness compared with traditional survey methods are discussed. Results indicate that using LANDSAT data is an economical and reliable method for monitoring natural resource use.

"Land Appreciation Rates and Economic Justification of Land Values." Glenn A. Helmers and Myles J. Watts (University of Nebraska)
A capital budgeting model is applied to land investments. Yearly net incomes from land are assumed to be less than opportunity costs yielding negative yearly net economic flows. Land appreciation rates necessary to economically justify the investment are determined on a before and after-tax basis.

Decision Making Under Risk (A. Gene Nelson, Oregon State University, Chairman)

"Teaching Decision Making Under Risk and Uncertainty to Farmers." John Holt (University of Florida) and Kim B. Anderson (Oklahoma State University)
A manager's central role is making choices among uncertain outcomes. A teaching approach is reported that can help managers analyze the component parts of a decision, clarify the risk involved in each action, and help to analyze that risk in a systematic manner. The analysis—whether or not to graze stocker cattle on wheat—embodies production and marketing risk for both cattle and wheat.

"A Direct Solution Alternative to E-V Analysis in Utility Maximization Models." Edward E. Ives (Governor's Energy Advisory Council, Texas)
Utility maximization models of farm cropping decisions typically use E-V analysis as a solution technique, requiring the solution to a number of quadratic programming problems. The problem can be solved using a single quadratic programming problem. The direct solutions advantages may sometimes be outweighed by other factors, however.

"Incorporating Multiple Sources of Risk into the Determination of Optimal Fertilization Rates." Hovav Talpaz and C. Robert Taylor (Texas A&M University)
A theoretical framework for incorporating three sources of risk—weather, price, and production response—is presented. The decision criteria considered are the maximization of profit subject to risk constraint, where risk is defined as the probability of not recovering cost of fertilization. A two-source risk numerical application is provided.

"A Bio-Economic Model of Beef, Forage, and Grain Production for Western Canada." Bernard H. Sonntag and Kurt K. Klein (Agriculture Canada)
Multidisciplinary research can provide a better understanding of agricultural production problems. A bioeconomic model of beef, forage, and grain production is described in terms of its biological and economic components. Special applicabilities for this type of model are noted.

"Expected Return and Risk—A Trade-Off in Farm Enterprise Choice." Bryan W. Schurle and Bernard L. Erven (Ohio State University)
A modified linear programming alternative, Hazell's MOTAD model, is used to address an enterprise choice problem in which the enterprise alternatives differ substantially in average net return and risk. Examination of several specific questions related to the trade-offs between return and risk demonstrate the model's usefulness.

"Procedures for Estimating Exponential Utility Functions." Steven T. Buccola (Virginia Polytechnic Institute and State University)
Exponential utility functions have the desirable feature of constant absolute risk aversion but present estimation problems. Logarithmic transformations of these functions do not conform to Von Neumann-Morgenstern axioms and hence cannot be used as bases for a best fit. A proper criterion for selecting such a fit is described.

Award-Winning Theses

Holliday, Douglas C. "An Analysis of Economic Relationships and Performance in the Canadian Broiler Industry." M.Sc. thesis, University of Guelph, Canada, 1976.

This study quantifies economic relationships in the North American broiler chicken industry for the purpose of investigating the performance of marketing institutions in this sector. The economic problem is set in the confines of marketing board policy in Canada. A recursive spatial equilibrium model of the Takayama and Judge type was constructed to provide the framework for the analysis.

This analysis of performance was questioned, however, because of the difficulty encountered in defining an overall measure from which to draw concrete conclusions. Potential impacts of selected modifications to the market structure were studied. Two types of modifications were studied. These included the removal of past or present structural characteristics that were built into the validation model and an analysis of several potential changes to the existing market structure. The latter considered the establishment and operation of a national marketing agency in Canada.

The removal of the artificial trade barrier between Canada and the United States suggested *(a)* that the methods of costing and pricing used by provincial boards tend to overinflate prices, *(b)* that past pricing practices have jeopardized the long-run import position of the Canadian industry, and *(c)* that past price levels in Canada could have been obtained only through the control of imports.

Several policies concerned with the formation of a national agency in Canada were simulated. One policy suggested that the quota control mechanism of the Ontario Board has been unduly restrictive relative to that of other provincial boards. The second policy showed a substantial increase in revenue to Canadian producers and a consequent reduction in consumer welfare if imports from the United States were controlled. The final policy showed an aggregate benefit to the Canadian industry through the reallocation of regional market shares on the basis of population growth.

Novakovic, Andrew M. "The Impact of Imports of Manufactured Milk Products on the United States Dairy Industry." M.S. thesis, Purdue University, 1976.

In 1973 and early 1974, the U.S. government relaxed traditionally tight import quotas for American cheese, butter, and nonfat dry milk in an effort to reduce higher than normal dairy prices. These actions sparked a debate over the effect of imports on the dairy industry. The principal objective of this thesis is to estimate the impact of changes in the level of dairy imports upon the production, consumption, and prices of major dairy products and raw milk.

To this end an econometric model of the U.S. dairy industry is developed. The model describes retail and wholesale level markets for fluid milk products, American cheese, butter, nonfat dry milk, and frozen desserts as well as the farm level supply of raw milk. The farm supply of raw milk includes a capital-theoretic herd adjustment component. The model is estimated using two-stage least squares. The Gauss-Seidel procedure is then recursively applied to trace out the time paths of adjustment of consumption, production, and price of dairy products and raw milk under three alternative levels of manufactured milk product imports.

Results of the analysis indicate that, as imports increase, prices and production decrease while consumption increases. More significantly, the analysis indicates that much larger than normal import levels are required to bring about a substantial impact upon the dairy industry.

Rosera, Eugene S. "The Economic Impacts of Industrialization on a Rural Louisiana Economy: LaSalle Parish." M.S. thesis, Louisiana State University, 1976.

The objective of this study was to identify, by selected economic and demographic measures, the impact of industrialization on a rural Louisiana economy. Economic impacts generated by industrial and other sector output increases were estimated through a modified input-output model. Sectors comprising the LaSalle parish economy were identified and sample data were collected from 65 households, 81 businesses, and government sources by personal interview. Intersectoral trade effects were described by output multipliers, income and employment effects and multipliers, and the components of those measures attributable to the industrial sector were identified. It was estimated that, per dollar output increase by any parish sector, the greatest output impacts generated by manufacturing occurred due to its household sector payments and resulting induced effects.

A sample of 321 new industrial sector employees was used to estimate selected demographic and economic changes not measured by the input-output model. A profile of employee demographic characteristics was developed. The previous employment status and changes in employment and salary levels of workers were estimated. A survey of 27 of 29 businesses that opened or expanded

during the period of manufacturing growth was used to estimate other parish employment increases. Additionally, the expenditure of resident manufacturing employee salaries to local businesses was estimated.

Direct public costs of attracting and installing industrial production facilities in the parish were determined through a survey of local governments.

Barros, Geraldo Sant'Ana de Camargo. "Asking Wages, Market Wages, and the Off-Farm Labor Supply by Farm Operators." Ph.D. thesis, North Carolina State University, 1976.

The objective of this study was to investigate the factors affecting the farmer's decision to participate in the off-farm labor market. The problem was analyzed with a theoretical model of multiple job holding in which household and farm activities determined the farmer's value of time. A logit analysis was applied to estimate the effect of several variables on the probability of working off farm. Weighted regressions were used to estimate the offered wage equation and the hours of work equation. The entire procedure led to consistent and asymptotically efficient estimation of a common set of parameters that underlie the function determining the probability that an operator works off the farm, his hours of work, his market wage, and his asking wage.

The model was tested by using data from a 1971 survey of farm operators in Illinois. The results indicated that the operator's schooling affected positively and with equal intensity both the asking wage and the offered wage. The effect of operator's schooling on the probability of working and the hours of work off farm was negligible. Farm operators tended to work longer until middle age and then reduce hours of work. Area operated, hours of family labor employed on the farm, the wife's schooling level, and farm experience were negatively related to the probability of working and to hours of work off farm. Operator's previous job experience and operator's health were positively related to the probability of working and to hours of work off farm.

Bockstael, Nancy Elaine. "Analysis of Investment Behavior and Price Determination: Analytical Input for the Formation of Policy in the Fisheries." Ph.D. thesis, University of Rhode Island, 1976.

The Fisheries Conservation and Management Act of 1976 defines the term "optimum" as that "which will provide the greatest overall benefit to the nation," implying that the objectives of the act extend beyond the welfare of the fishing industry. Policy decisions regarding allowable level of foreign fishing will affect the actual gains accruing from diminished foreign fishing and the distribution of those gains among U.S. interest groups. Rational decision making will require an understanding of consumer demand, retail and exvessel price determination, and U.S. fishermen's supply response, such that the impact on domestic producers and consumers can be predicted from initial exogenous changes.

This study's objective was to provide two segments of a comprehensive, dynamic model. The first segment of the study modeled disaggregated firm investment behavior in the U.S. groundfish industry using logit analysis. The feasibility and usefulness of logit analysis for handling the complications introduced by fishery investment behavior was demonstrated, and promising results were achieved for two partitions of the data set—those who changed capital stock and those who entered the fishery. Fishermen's decisions were explained in terms of differences in gross revenues and capital costs associated with different capital stock alternatives. A tendency towards inertia was identified.

The second segment, an econometric analysis of the behavior of economic agents in the groundfish market, was successful in explaining the interaction of consumer demand, imports, and domestic landings in determining exvessel groundfish prices to domestic fishermen and retail prices of various groundfish products. Results supported the hypothesis that foreign groundfish harvesting within the U.S. 200 mile zone affects U.S. import prices, and thus all U.S. groundfish prices, through the mechanism of the world market.

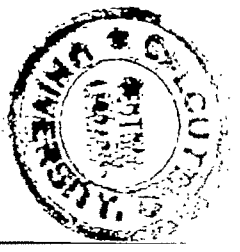
Dixon, Bruce Lawrence. "A Stochastic Control Approach to Harvest Scheduling in a National Forest." Ph.D. thesis, University of California, Davis, 1976.

A natural resource manager faces the empirical problem of intertemporally allocating product flows and resource stocks under conditions of uncertainty. The timber management problem of national forests is conceptualized in this study as a stochastic, optimal control problem. Theoretical procedures exist to obtain optimal solutions to stochastic control problems, but the computational requirements for even moderately sized problems are excessive. Hence, approximate solution techniques are employed.

The approximate solution technique used is the linear-quadratic-Gaussian (LQG) control method. The optimization philosophy of the LQG method is to keep the actual evolution of the resource system "close" to a set of predetermined stock and control levels. The method utilizes Taylor's theorem to construct a simplified model of the original problem. This model is characterized by quadratic preferences and linear growth dynamics. The solution to the problem given by the simplified model is quickly computed, allowing the policy maker to

determine the harvest flows under a wide spectrum of policies. The costs of various sources of uncertainty are also derived as part of the solution.

The LQG method is applied to timber management of mixed conifer stands of a California national forest. The experimental results show that timber flows change markedly when nonstumpage uses of timber are recognized explicitly in the objective function. This result underscores the need to be able to quantify and evaluate multiple-use values accurately. The recursive estimator used in the LQG model results in an estimate of timber stocks with a lower variance than conventional static estimators.



Committee Reports

Report of the President

I have enjoyed the opportunity to serve as president in 1976–77 and to contribute in some small way to the advancement of the Association and the profession. Although I had served on the Executive Board four consecutive years prior to becoming president, I had not fully appreciated the scope and complexity of AAEA activities until 1976–77. I look forward to relief from some burdens that accompany the office, but I nevertheless leave the office with feelings of optimism and excitement concerning opportunities for the Association to better serve the diverse interests of its members and society.

In my judgment the keys to development of the Association are to be found in continued support of high standards of scholarship, independence and objectivity of inquiry, tolerance and encouragement of differing professional viewpoints, and selective expansion of services to better serve the interests of groups of members—students, newly established professionals, and the several institutional, subdisciplinary groups—that comprise our membership.

The single greatest need and opportunity for the Association is that of better relating the profession to current and emerging socioeconomic issues of our times concerning food, agriculture, resources, people, and communities. I believe the Association can perform in that role to the long-run benefit of its members and society and at the same time continue to serve its prime purpose of advancing the scientific, scholarly content of the profession of agricultural economics. To do so, agricultural economists must find ways of relating more effectively to other disciplines with whom we must interact in resolution of complex socioeconomic issues, and the officers and members must develop a viewpoint that the Association has purposes both internal and external to the profession. There is, I believe, the interest, capacity, and leadership in the profession to achieve those goals.

The affairs of the Association are conducted in large part through its committee structure. Currently, there are fifteen standing committees, seventeen special committees, and three ad hoc committees. We have six liaison representatives to other organizations. In total nearly 260 members were involved in committee activities in 1976–77. The work of these committees is essential to the Association, and whatever the accomplishments of the president and the Board, they derive usually from the work of such committees. I appreciate the excellent assistance given by all committees to me and the Board during 1976–77.

One ad hoc committee and one major special committee were created during the year. The ad hoc committee was created to review policies and procedures concerning the *Journal* page charge. A special committee on business organization and management was charged with responsibilities of reviewing the management structure, methods, and procedures of the Association and recommending steps that might be taken to improve effectiveness of our operations and managerial processes.

Several conditions give rise to the need for this review. Foremost is the growing complexity of the Association as we strive to develop services to meet the diverse needs of the membership. The development and delivery of these services is dispersed among several institutions and locations and requires substantial managerial efforts by the president, secretary-treasurer, and committee chairmen. The annual turnover in members of the Executive Board and committees poses problems in maintaining continuity in management. The secretary-treasurer is called upon to perform a myriad of functions, some above and beyond those of a secretary or a treasurer. Routine management duties limit the ability of the president to concentrate on broad policy matters of the Association. A need exists to review possible application of modern data and information processing techniques in the executive affairs of the Association.

This committee, under chairmanship of Burt Sundquist, University of Minnesota, has been assigned a large, complex task. They have been asked to file a final report with the Board in the summer of 1978.

One of the most important decisions of the Board during the year was selection of new editor and associate editor of the *Journal*—V. J. Rhodes and S. R. Johnson, respectively, of the University of Missouri. The transition from Cornell University to the University of Missouri has been largely completed. The February 1978 issue will be the first official output of the new editors. We are indebted to W. G. Tomek and Cornell University for their support during the past three years and to the University of Missouri for the support they will be providing in the next three years.

Two of the most visible products of the year were the new *Handbook-Directory* and volume 1 of *A Survey of Agricultural Economics Literature*. As of 1 September 1977, sales of volume 1 totaled 480 copies. Volume II of the *Survey* will be published in late fall 1977. Work on volume III is nearing completion with projected publication in late 1978. The *Handbook-Directory*, totaling over 600 pages, represents an important personal contribution of John Redman and his staff. We are indebted to them for their diligence and persistence in compiling the publication. To economize on labor and other costs, the

Employment Services Committee has examined the feasibility of publishing the next edition of the *Handbook-Directory* from the computerized professional registry. With some modifications and expansion of inputs the registry would appear suitable for such purposes. We shall further explore those possibilities in the year ahead.

Another major decision of the Board relates to the professional (employment) registry service. Since its inception in 1974, the computerized employment registry has been financed solely by grants from the U.S. Department of Labor. A final funding grant was received during the year to extend operation of the registry to 15 February 1978. In anticipation of expiration of the grant, the Board asked the Professional Registries Committee, under chairmanship of Dave Boyne, Ohio State University, to examine alternative institutional arrangements for continuation of the registry on a permanent user-sustained basis. The committee also was asked to explore means of expanding the scope of the registry for the purpose of educational-manpower planning.

The Board has approved a plan whereby the registry will be housed in the U.S. Department of Agriculture (Economic Research Service) and financed by annual grants from institutions that might use the registry services. For U.S. and Canadian agricultural economics departments, annual grants of $50 to $300, depending upon the number of faculty, have been solicited. Grants of $100 are being solicited from agricultural business organizations. Solicitations have been sought from the Ford Foundation, U.S. Agency for International Development, and USDA agencies.

Based upon response to these solicitations it appears that grants might total $15,000 in 1978. With the placement officer to be provided by ERS, the Board concluded that these grants would be adequate to sustain operation of the registry in 1978 at near current levels of activity. Thus, the Board has authorized formal acceptance of grants and development of an agreement with the ERS. Similar financing arrangements will likely be extended to 1979 and 1980.

Although these arrangements meet our immediate financial needs and provide for continuation of the service at current levels, a concerted effort is needed to increase the number of registrants, maintain currency of information in the registry, and encourage use of the system by employers of agricultural economists.

In my presidential address, I recommended that the Association initiate activities to encourage expanded and more effective public policy research and education programs. I am pleased that the Board has seen fit to establish a new Distinguished Policy Contribution Award, which may be awarded annually beginning 1977–78. The Board also adopted a policy statement to encourage AAEA sponsorship of seminars, workshops, symposia, colloquia, and other professional activities in the interest of a significant proportion of the membership or a recognized subset of members. I hope that you will offer suggestions for such activities to the incoming president and the Professional Activities Committee.

A year ago the Board adopted policies to limit membership on AAEA committees and presentation of papers at annual meetings to AAEA members except as the condition is waived by the president. A differential member-nonmember fee structure at annual meetings was also authorized and has been implemented. I encountered no major difficulty in implementing these policies. I have judiciously utilized authority to waive the membership requirement particularly when I felt the requirement was not consistent with the need for participation in the annual meeting by persons from other disciplines or by persons who could not be expected normally to be AAEA members by virtue of their profession or position.

Including those who paid membership dues at the 1977 summer meeting, it appears that we have maintained individual membership and increased institutional membership in 1977 relative to 1976. Given higher dues and the one-time membership-increasing effect of the *Handbook-Directory* in 1976, this is a satisfactory achievement, attributable in no small part to the work of the Membership Committee under chairmanship of John Lee. The secretary-treasurer reports more fully on membership.

The Membership Committee initiated several activities during the year to systematize recruitment of members. These include automation of membership lists of AAEA, the regional associations, and the Canadian Agricultural Economics Society including lists of potential members and development and circulation of a membership information leaflet.

The Alternative Publications Committee, under chairmanship of Verner Hurt, is examining information services of the Association including the *Journal*. A report for action by the Board will be filed in late 1977.

Just a few comments on the summer 1977 meeting in San Diego. It was a unique occasion with respect to AAEA meetings—the first in more than 40 years held in commercial facilities. One of the major differences from meetings on university campuses is the fact that no local arrangements committee existed to which we could delegate the numerous decisions concerning lodging, room arrangements, equipment, travel, printing of program, etc. This meant that the burdens of those tasks have fallen upon relatively few individuals.

However, thanks to the hard work and support of those individuals it has been, on balance, a good experience. It has been a pleasure to share responsibilities with William E. Martin, president, Western Agricultural Economics Association. He has been imaginative, cooperative, and understanding

even at times when he must have questioned the jointness of planning and decision making.

I must acknowledge the steadfast support of my secretaries, Mildred Evano, Carol Kotch, Sharon Warwick, and Geneva Riddle, who have worked very hard in preparation of this meeting. Loyd Martin of the ERS has worked hard throughout the year in carrying out decisions with respect to program, travel, lodging, and committee functions.

The staff of the Town and Country Hotel have been efficient, professional, and responsive to our every need within constraints of the facility. Patt Potter, in particular, has been decisive, well organized, and helpful.

We are indebted to John Redman and his staff. In addition to regular duties that attend these meetings, John assumed major responsibilities for advance publicity of the meeting, printing of the program and other brochures, catering arrangements, registration procedures, and other duties too numerous to mention. He has served cheerfully and competently with, as usual, the best interests of the Association in mind.

I also wish to acknowledge the assistance of James Boles, University of California, Berkeley, B. C. French, University of California, Davis, and Jimmye Hillman, University of Arizona, and graduate students from each of those institutions for their assistance in operating employment services at the meeting. Finally, I appreciate the assistance being provided by the San Diego Convention Bureau at the registration desk and by Pacific Telephone at the message center.

I wish to thank retiring board members Fred Mangum and B. F. Stanton for their three years of thoughtful effort on behalf of members of the AAEA. Bud Stanton, of course, will be serving on the Executive Board for three more years in his presidential capacities.

It has been a pleasure for me to work with the current Executive Board. They have worked diligently and harmoniously with me even through grueling Board meetings. To Past-President James Bonnen, who set in motion many of the initiatives I have pursued this year, I am grateful for sage advice and insights even late at night!

I now turn the presidency over to R. James Hildreth. Jim, please accept my thanks for your assistance in the past year and my very best wishes for the coming year. I am sure I speak for the new Board and our members in saying that we stand ready to do everything possible to make your year as president a productive one. Congratulations and good luck.

Kenneth R. Farrell, President

Resolutions

Wishing to acknowledge the support given to the *American Journal of Agricultural Economics* during the past three years, be it resolved that the American Agricultural Economics Association expresses its appreciation to Cornell University and to the Department of Agricultural Economics of Cornell University for the support given the *American Journal of Agricultural Economics*. The special thanks of the Association are due the editor, William G. Tomek, the associate editors, Richard N. Boisvert and Donald K. Freebairn, and the assistant editor, Nancy M. Larrabee, as well as the Editorial Council for their outstanding services. In addition the Association wishes to express its deep appreciation to Francis E. Walker of Ohio State University for his services as book review editor.

Be it further resolved that a copy of this Resolution be sent to the appropriate administrative officials of Cornell University and Ohio State University.

Wishing to acknowledge the contributions made to production of the 1977 AAEA *Handbook-Directory*, be it resolved that the American Agricultural Economics Association expresses its appreciation to John C. Redman and Willetta Hager for the many long hours of hard, demanding work, without which the 1977 *Handbook-Directory* would not have been possible.

Be it further resolved that a copy of this resolution be sent to the appropriate administrative officials of the University of Kentucky.

Report of the Secretary-Treasurer

The AAEA membership for 1976 totaled 5,841 as compared with 5,966 for 1975, a decrease of 125 members (table 1). Two opposing forces affected membership—the publication of the *Handbook-Directory* and a dues increase. If history repeats, 1977 will be a critical year. A bylaws amendment authorized the corresponding membership category to be combined with the regular membership and the establishment of a senior membership category for those who have reached the age of 65 and retired from active professional work. The number of members who had paid on or before 1 April 1977, and therefore received a ballot to vote, remained close to the previous two years (table 2).

The operating statement for 1976 showed a surplus of $17,349.95, which is good news, particularly since a deficit was experienced for each of previous three years (table 3). Caution must be exercised in analyzing operating statements because extraordinary items often convey normal activity. The U.S. Department of Labor (USDL) grant to support the activities of the Employment Committee was separated this year into its own operating statement (table 4). Since we are the custodian of these funds, this separation gives a more accurate indication of our financial activity.

On the income side, two significant changes are to be noted. The large increase in income from dues and subscriptions resulted from the dues increase

Table 1. Number of Members and Subscribers, 31 December 1970–76

Category	1970	1971	1972	1973	1974	1975	1976
Institutional members	39	34	25	20	22	25	26
Regular members							
U.S.	2,667	2,856	2,802	2,504	2,756	2,779	2,731
Foreign	534	486	601	487	480	503	766
Senior members[a]	0	0	0	0	0	0	47
Junior members							
U.S.	494	635	398	316	338	484	483
Foreign	84	53	38	161	68	66	49
Corresponding[b]							
U.S.	4	2	0	0	1	2	0
Foreign	95	100	82	184	198	207	0
Libraries and businesses							
U.S.	596	619	647	635	667	670	572
Foreign	1,031	1,111	1,196	1,168	1,242	1,227	1,164
Exchange	3	2	2	3	3	3	3
Total	5,547	5,898	5,791	5,478	5,775	5,966	5,841

[a] New category established in 1976.
[b] Category combined with regular members in 1976.

made effective 1 January 1976. Also, the page charge that was collected for the first full year produced a sizable increase. The miscellaneous income included $123 for postage collected for remailing the *Journal* and $100 return from the International Association of Agricultural Economics grant.

On the expense side, printing bills were paid for six issues of the *Journal* instead of five. Included in the $15,207.76 literature review expense was a grant in aid of $15,000 made to the University of Minnesota Press for publishing two volumes of reviews. The miscellaneous expense of $810.30 was comprised of $509.00 in refunds, $225.00 for dues to the Federal Statistics Users' Conference, $36.00 for copyright fees, $6.00 for Iowa registration fee, and $34.30 for IRS assessment.

As you are aware, the AAEA received a grant to develop a computerized national registry and employment service for agricultural economists. In previous reports, these funds were included in the operating statement and, with unexpended balances, misleading impressions of financial activity may have been conveyed. Thus, the USDL grant funds were separated (tables 4 and 6). The year ended with a deficit of $753.05, but it was known that the grant had been extended with additional funding.

In accordance with the policy established in 1973, the income-expense statement for editorial support as provided by the editor is incorporated as a part of this report (table 5).

The balance sheet for the AAEA (table 6), which had deteriorated rapidly over the past three years, improved considerably because of the positive balance of $17,349.95 (see table 3). Again, the unspent USDL funds were carried separately to give a better indication of our net worth. A second item of note is that the total assets are carried at cost. The approximate market value is for information only and is not included in the totals. A third item lies in the item of prepayment of dues. The 1975 figure was prepayment for 1976, the year of the *Handbook-Directory*. The year 1976 was for 1977 with no *Handbook-Directory*, and the amount paid with a dues increase was approximately the same as the previous years. As stated at the beginning of the report, 1977 may be a critical year.

The year 1976 was extremely busy for me with the preparation of the *Handbook-Directory* and the increased number of activities and requests, but I enjoyed every minute.

John C. Redman, secretary-treasurer

Table 2. Number of Members on 1 April, Ballots Mailed and Returned, 1974–77

Category	1974	1975	1976	1977
U.S. members	2,401	2,746	2,878	2,721
Canadian members	178	156	175	170
Foreign members	248	592	443	452
Total ballots mailed	2,827	3,494	3,496	3,343
Total ballots returned	1,920	1,850	1,624	1,751

Report of the Audit Committee

The Audit Committee employed the accounting firm of Moore, Wilson & Smith to examine the financial records of the AAEA in 1976. Their report is as follows.

"We have examined the balance sheet of the American Agricultural Economics Association as of December 31, 1976, and the related statement of receipts and disbursements, fund balance and

Table 3. AAEA Operating Statements, 1974–76

Item	1974	1975	1976
Income ($)			
Dues and subscriptions			
Regular members	53,723.13	55,545.54	87,951.61
Senior members	0	0	537.50
Junior members	2,607.92	4,295.14	8,294.28
Subscriptions	38,430.19	39,531.64	56,534.56
Corresponding	930.00	1,940.00	3,540.00
Institutional	2,200.00	2,500.00	2,600.00
ABAE-literature retrieval	5,261.76	3,283.56	0
Journal publications			
Journal sales	5,273.75	5,714.20	5,156.00
Page charges and reprints	4,452.50	9,575.50	26,700.50
Advertisements	819.64	824.80	1,375.50
Royalties	0	979.80	557.77
Other	0	184.61	0
Postwar Literature Review sales	0	0	569.00
Investments	8,593.25	9,040.60	9,535.75
Annual meeting	4,193.34	269.80	710.27
Address labels	935.40	557.96	1,215.92
Miscellaneous	16,335.53[a]	278.84	223.00
Total ($)	143,756.41	134,521.99	205,501.66
Expenses ($)			
Journal			
Printing	81,752.64	79,324.15	95,703.42[b]
Editorial support	23,400.00	17,700.00	20,000.00
Printing reprints	3,152.71	2,285.23	2,892.23
Purchase *Journals*	569.64	323.90	165.00
ABAE-literature retrieval	10,655.14	18,862.22	13,942.20
Postwar Literature Review	0	0	15,207.76
AAEA (International Conference) grant	0	0	5,000.00
Handbook-Directory	0	0	2,794.04
Awards	1,500.00	1,500.00	1,500.00
Student activities	1,129.89	0	0
General operations			
Postage and phone	2,962.58	3,879.52	4,465.89
Office supplies and printing	2,385.91	4,330.22	2,811.80
Annual meeting	4,460.74	1,712.94	1,270.88
Committees	357.25	460.27	1,211.38
Bonds	149.00	149.00	149.00
Audit	200.00	400.00	500.00
Secretary-treasurer assistant	13,874.50	14,000.83	15,727.81
Secretary-treasurer honorarium	4,000.00	4,000.00	4,000.00
Miscellaneous	15,435.83[a]	849.66	810.30
Total ($)	165,985.83	149,777.94	188,151.71
Balance ($)	−22,229.42	−15,255.95	17,349.95

[a] Includes $15,000 Rockefeller Grant received and expended.
[b] For six issues of the *Journal*.

Table 4. U.S. Department of Labor Grant Operating Statement

Item	1973	1974	1975	1976
Beginning balance ($)	0	25,100.34	7,434.10	8,844.22
Amount received ($)	37,500.00	32,000.00	49,500.00	22,000.00
Expenses ($)	12,399.66	49,666.24	48,089.88	31,597.27
Ending balance ($)	25,100.34	7,434.10	8,844.22	−753.05

Table 5. Income-Expense Statement of Editorial Office, 1976

Income ($)	
AAEA appropriation	20,000.00
Expenses ($)	
Salaries	
Assistant editor	9,700.00
Secretary	7,201.40
Postage	2,248.00
Copying	492.05
Telephone	581.27
Supplies	463.44
Total	20,686.16
Balance ($)	−686.16

changes in financial position for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

"In our opinion, the financial statements referred to above present fairly the financial position of the American Agricultural Economics Association as of December 31, 1976, and the results of its operations and the changes in its financial position for the year then ended in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year."

Report of the Investment Committee

The portfolio of the AAEA, which did not change during 1976, produced an income of $9,535.75. The stocks carried on the books at cost of $102,551.99 had a market value of $202,490.50 on 31 December 1976, increasing by $43,180.375 from the previous year (table 1). Our investments in stocks yielded $9,527.32 in dividends (table 2).

All stocks were worth more at the end of 1976 than at the beginning. Five stocks—American Cyanamid, Commonwealth Edison, Goodyear, Jewell Tea, and Texaco—were worth less than their cost. However, the total value was about two times the cost. Based on cost, the stocks produced a 9.3% return, but when based on value at the beginning of the year the yield was 6.0%.

John C. Redman

Table 1. Summary of Investments, Year Ending 31 December 1976

	Income ($)	Value ($)	
		Cost	Market
Stocks			
On hand, 1 Jan. 1976		102,551.99	159,310.125
On hand, 31 Dec. 1976		102,551.99	
Dividends	9,527.32		
Ready asset trust	8.43	7,546.43	
Certificate of deposit	0	40,000.00	
Total	9,535.75	150,098.42	

Table 6. Combined Balance Sheet, 31 December 1976, with Comparisons

	1973	1974	1975	1976
Assets ($)				
Cash-bank	81,117.43	54,195.05	54,940.54	12,321.25
Cash-bank, USDL	25,100.34	7,434.10	8,844.22	0
Cash-UK	(135.99)	291.25	1,714.21	3,510.28
Cash-broker	2,123.08	1,896.63	10,937.23	1,546.92
Prepaid expenses	0	8,850.00	0	0
Investments ($)				
Certificate of deposit	0	0	0	40,000.00
Ready asset	0	0	0	7,546,99
Stocks (at cost)	102,551.99	102,551.99	102,551.99	102,551.99
Approximate market value	182,886.125	136,432.625	159,310.125	202,490.50
Total assets (at cost) ($)	210,756.85	175,219.02	178,988.19	167,476.87
Liabilities ($)				
USDL unspent funds	25,100.34	7,434.10	8,844.22	753.05
Prepaid dues	27,895.67	32,253.50	49,868.50	30,604.50
Accounts payable	30,116.10	30,116.10	30,116.10	30,116.10
Net worth	127,644.74	105,415.32	90,159.37	107,509.32
Total liabilities ($)	210,756.85	175,219.02	178,988.19	167,476.87

Table 2. Value of AAEA Stocks

Company	No. of Shares	Original Cost ($)	Dividends 1976 ($)	Market Value ($) 31 Dec. 1975	Market Value ($) 31 Dec. 1976
Amer. Cyanamid	250	9,143.43	375.00	6,218.75	6,968.75
Amer. Tel. & Tel.	288	11,421.11	1,065.60	14,652.00	18,288.00
Amer. Tel. & Tel. $4CV	300	16,934.00	1,200.00	16,537.50	19,950.00
Borden	228	2,162.41	307.80	6,070.50	7,752.00
Chase Manhattan	93	1,115.09	204.60	2,557.50	2,848.125
Clark Equipment	600	2,200.67	1,020.00	15,075.00	25,425.00
Con. Edison	232	7,467.14	551.00	7,018.00	7,337.00
Cont. Group[a]	225	4,315.38	416.25	6,187.50	7,621.875
Exxon	306	10,325.36	833.85	13,578.75	16,409.25
Goodyear	500	16,692.50	550.00	10,875.00	11,875.00
Jewell	150	3,875.94	187.50	2,000.00	3,581.25
NICOR	7	—	13.32	156.625	208.25
Sears Roebuck	304	1,845.38	562.40	19,608.00	20,976.00
Standard Oil Ind.	800	7,356.68	1,840.00	34,100.00	47,700.00
Texaco	200	7,696.90	400.00	4,675.00	5,550.00
Total		102,551.99	9,527.32	159,310.125	202,490.50

[a] Name changed from Continental Can in May 1976.

Report of the Finance Committee

The primary activities of the Finance Committee since the January 1977 meeting of the Board have been to monitor income and expense experience of the Association for 1976 and 1977, prepare materials for the 1978 budget (tables 1, 2, and 3), develop guidelines for cash flow and account transac-

Table 1. AAEA Expense Statements and Budgets

Description	Actual Expenses ($) 1974	1975	1976	Budgets ($) 1977	1978
Journal					
Printing, postage, etc.	81,753	79,324	95,703[b]	85,000	83,500
Editorial support	23,400	17,700	20,000	30,000	22,500
Printing reprints	3,153	2,285	2,892	3,000	2,500
Purchase *Journals*	570	324	165	0	200
ABAE-literature retrieval	10,655	18,862	13,942	16,000	15,400
Postwar Literature Review	0	0	15,208	7,500	7,500
Postwar book order	0	0	0	0	8,750
Employment committee	0	0	0	0	15,000
AAEA (International Conference) grant	0	0	5,000	0	0
Handbook-Directory	0	0	2,794	10,000	0
Awards	1,500	1,500	1,500	1,500	1,500
Students activities	1,130	0	0	0	0
General operations					
Postage and phone	2,963	3,880	4,466	7,000	8,000
Office supplies and printing	2,386	4,330	2,812	4,000	3,500
Annual meeting	4,461	1,713	1,271	2,000	1,500
Committees	357	460	1,211	1,200	1,000
Bonds	149	149	149	150	150
Audit	200	400	500	600	600
Secretary-treasurer assistant	13,875	14,001	15,728	16,000	17,000
Secretary-treasurer honorarium	4,000	4,000	4,000	4,000	5,000
Miscellaneous	15,436[a]	850	810	3,250	3,000
Total expenses	165,988	149,778	188,151	191,200	196,600

[a] Includes $15,000 Rockefeller Grant (compensating entries).
[b] Six issues.

Table 2. AAEA Income Statements and Budgets

Description	Actual Income ($)			Budgets ($)	
	1974	1975	1976	1977	1978
Dues and subscriptions					
Regular members	53,723	55,546	87,952	82,500	85,000[b]
Senior members	0	0	538	0	625
Junior members	2,608	4,295	8,294	6,250	6,250
Subscriptions	38,430	39,532	56,535	57,400	59,150
Corresponding	930	1,940	3,540	0	0
International	2,200	2,500	2,600	2,500	4,000
ABAE-literature retrieval	5,262	3,284	0	0	0
Journal and publications					
Journal sales	5,274	5,714	5,156	4,500	5,000
Page charges and reprints	4,453	9,576	26,701	24,500	24,000
Advertisements	820	825	1,376	1,000	1,500
Royalties	0	980	558	0	600
Other	0	185	0	0	0
Postwar Literature Review	0	0	569	0	9,000
Investments	8,593	9,041	9,536	10,000	12,000
Employment committee	0	0	0	0	12,000
Annual meeting	4,193	270	710	1,000	1,000
Address labels	935	558	1,216	1,000	1,000
Miscellaneous	16,336[a]	279	223	0	300
Total income	143,757	134,525	205,504	190,650	221,425
Total expenses	165,988	149,778	188,151	191,200	196,600
Balance	−22,231	−15,253	17,353	−550	24,825

[a] Includes $15,000 Rockefeller grant (compensating entries).

[b] Dues and subscriptions estimates for 1978 based on: regular members—3,400 at $25.00 = $85,000; senior members—50 at $12.50 = $625; junior members—500 at $12.50 = $6,250; subscriptions—1,100 at $31.50 = $34,650 and 700 at $35.00 = $24,500; and institutional—40 at $100.00 = $4,000, for a total of $155,025 from 5,575 members and subscriptions.

tions for the office of secretary-treasurer, and consider alternative methods of managing the investment portfolio and recommend a procedure for future management.

The committee is pleased to note that the AAEA's final operating statement for 1976 showed a positive balance after three successive years of deficits. Projections for 1977 also indicate a positive balance is likely. We commend the secretary-treasurer and all the operating groups for their efforts to work within budget guidelines.

Individual members of the finance committee have followed one or more of the Association's important enterprises and activities to monitor expenditures and assist in developing the budget. Assignments were Barr—*Journal*, Barry—literature retrieval, Boehlje—employment, and Stanton—office of secretary-treasurer.

During the year the committee met twice by use of conference call and once for an all day meeting in May in Washington, D.C., to develop initial budget estimates for 1978 and to prepare a recommendation for the Board on management of the investment portfolio.

With the assistance of the secretary-treasurer the committee developed the following set of general guidelines for cash flow and account transactions in that office:

(*a*) The Finance Committee is available to assist or advise the secretary-treasurer at any time if there are short-run decisions on transfers of funds or loans required.

(*b*) The secretary-treasurer has direct authority from the Board to borrow up to $25,000 for Association needs if required.

(*c*) Earnings from the investment portfolio will be forwarded automatically and deposited monthly into the checking account of the Association.

(*d*)) Cash and savings balances of the Association will be reviewed annually by the Finance Committee. Funds accumulated in savings, time deposits, or certificates of deposit will then be considered for appropriate investment in the AAEA portfolio.

(*e*) The following are suggested as guidelines with respect to maximum balances in individual accounts to hold at the commercial bank where AAEA accounts are located: checking account, $5,000; savings or time deposits, $20,000; and short-term certificates of deposit, multiples of $10,000.

The management of the investment portfolio has been under review for the past 18 months. Professional management has been investigated and discussed with the Board at two previous meetings. A report discussing external and internal management of the portfolio has been prepared (printed below) and a recommendation with procedures for internal management developed. We recommend that the Board take action on this proposal at the August 1977 meeting and that the procedures provided be

Table 3. Enterprise Budgets for Publication of the *Journal*

Description	Approved 1976 ($)	Approved 1977 ($)	Approved 1978 ($)
Expenses			
Printing 1,100 pages	77,500	80,000	76,000[a]
Postage	2,000	5,000	6,000
Storage, labor, other	0	0	1,500
Editorial support	20,000	20,000	22,500[b]
Editorial support, new editor	0	10,000[c]	0
Printing reprints	2,500	3,000	2,500
Purchase *Journals*	0	0	200
Total	102,000	118,000	108,700
Income			
Page charge ($40/page)	22,000	25,500	23,500[d]
Sale of reprints	500	500	500
Advertising	1,000	1,000	1,500
Submission fees, other	0	0	0
Total	23,500	27,000	25,500
Net enterprise cost	78,500	91,000	83,200

Note: An important part of the expenses associated with the office of the secretary-treasurer is directed to support of *Journal* activities.

[a] New printing contract starting 1 January 1977 with Heffernan Press on an issue of 1,100 pages has costs of $69 per page. The contract calls for no increase in printing charges for the second year and a maximum of 6% in the third year (1979). Paper and mailing cost increases can be passed on.

[b] Editorial support may need to be increased to reflect secretarial-clerical costs.

[c] A new editor for the *Journal* was appointed for the 1978–80 issues. Funds to operate during the transfer of the editor position were budgeted for July 1977 through 30 December 1977.

[d] Page charges are assumed collected on 585 pages at $40 per page.

implemented before the January 1978 meeting of the Board.

B. F. Stanton, chairman

Report on Management of the AAEA Portfolio

The investment portfolio of the American Agricultural Economics Association provides valuable revenue for ongoing operations, serves as a source of reserves in periods of need, and provides a credit rating for the Association. Although changes in the portfolio have occurred in the past, such transactions appear to have occurred infrequently and without thorough review of the portfolio. To obtain maximum benefits from the portfolio, systematic, periodic management is proposed. The purpose of this report is to discuss briefly some of the issues involved in comparing professional and internal (an AAEA committee) management of the AAEA portfolio and to propose a procedure for managing the portfolio in the future.

General Considerations

At least six factors should be considered in evaluating the management of the portfolio.

Quality of management. It is difficult to assess the quality of management without reference to a particular management service. However, one might expect improved management from a professional service compared with a committee of AAEA members because of (*a*) specialization in investment analysis and portfolio management, (*b*) accountability for management decisions, (*c*) more frequent portfolio analysis, and (*d*) size economies in transactions costs and acquisition of information. An AAEA committee might have or acquire the same characteristics as a professional service, although the commitment of time and effort would be substantial.

Costs. Recent discussions with trust departments of some large commercial banks indicate that the annual management fee charged for a portfolio of the size held by the AAEA would likely range from $1,300 to $1,600. This fee would include all transactions and reporting costs as well as management charges. This annual cost is roughly equal to 0.75% of the portfolio's current market value.

Returns. Evidence on the performance of professional management services is somewhat mixed and worthy of brief review. On one hand, one might expect the quality-of-management features outlined above to enable a professional management service to consistently beat the market; that is, to earn returns over and above the payment they command for their own services. The record certainly shows that there are investment funds that have outperformed random portfolios with equivalent risk. However, such superior performance is generally either limited to relatively short periods of time or, where it persists long, to a small enough number of firms that it could have occurred by chance. Moreover, these results are based on past performance with no certainty about performance in the future.

An alternative view cites increasing evidence on the inability of professional firms, or anyone else for that matter, to consistently outperform the market. This view is premised on the belief that the markets for equities and debt are indeed highly efficient in the sense that prices at any time reflect market judgment obtained from all available information. Furthermore, as new information (on earnings, production, losses, sales, discoveries, etc.) becomes available, it is so quickly reflected in current prices that no market participant can take action to benefit from it. Finally, if the new information becomes available in a random, unpredicted fashion, it will generate price movements that essentially follow a random walk.

Those analysts ascribing to the "efficient market hypothesis" believe that a "buy and hold" strategy will yield rates of return that are at least comparable

with and perhaps superior to those arising from any other investment strategy. The only potential for increasing expected returns occurs because some investments fall into higher risk classes than others and yield a higher expected rate of return to account for the greater risk. Hence, only a willingness by the investor to bear greater risk will lead to higher expected returns. These conditions lead to the following general investment strategy. First, choose a risk class of securities that is commensurate with the investor's risk preferences. Then buy and hold a well-diversified portfolio of securities within that risk class. The result is an expected rate of return that is as good or better than any other investment strategy. Finally, periodically monitor the portfolio to check for changes among risk classes in individual securities. Only changes among risk classes warrant portfolio revision.

The "buy and hold" is not a totally naive strategy. It requires identification of risk classes, effective diversification within the risk class, and monitoring for changes in risk classes. Hence, management is needed. In the AAEA's consideration of returns arising from external versus internal portfolio management, the key questions appear to be whether the AAEA could perform the tasks needed to follow a "buy and hold" strategy and, if so, whether its results would be comparable with those of professional management.

Willingness to act. One of the major concerns with respect to portfolio management is the willingness to act based on available information. A committee of AAEA members may be hesitant to act because of potential criticism that they may receive from colleagues if performance is below expectations or because of lack of strong consensus on the appropriate action. This type of problem could be solved by delegating responsibility to a professional management service.

Accountability. The payment for services rendered may lead to a higher degree of accountability for professional management than with internal management. In addition, inadequate performance may be more easily corrected in a professional service. Potential problems in interpersonal relationships in internal management could be reduced with professional management where termination of services could occur without concerns about criticizing personal friends and colleagues. In like fashion, discussions of lack of performance could occur without concern for the "personalities" involved.

Time commitment and timeliness. Portfolio management requires a commitment of time and timely decisions in response to market changes that warrant portfolio adjustments. A professional management service whose primary functions were to manage such portfolios would be compensated for making such a time commitment. In addition, a professional service that monitors financial markets more closely than an informal investment committee should be more responsive to market changes that warrant portfolio adjustments. However, the timeliness criterion may not be as crucial for internal management following an investment strategy suggested by the efficient market hypothesis.

A Specific Proposal

A specific procedure is recommended by the Finance Committee to manage the AAEA portfolio. It is a combination of the "internal" and "external" management options. In general, the procedure would involve the specification of goals concerning the desired performance of the portfolio (current income, growth in dividends, risk), periodic reviews of the portfolio by a brokerage house or investment service holding the account, and implementation of any recommendations concerning changes in the portfolio by a committee of AAEA members. Such a procedure would provide flexibility in utilizing the services of several advisory services if conditions warrant, would offer lower cash costs than the professional service option, and would enable the Association to move from growth-oriented equity issues to income-oriented debt issues as market rates or needs of the Association change.

The steps to be followed in implementing this procedure follow. (*a*) Specify and periodically review the goals concerning portfolio performance. These goals will include the risk, current income, and growth dimensions of the portfolio. For 1977 conditions the following objectives on performance are recommended: choose a low risk portfolio of securities, achieve a 7.0% annual rate of return, and achieve a 5.0% rate of growth in dividend payout. Initially, the portfolio will be comprised approximately of 85% equity issues and 15% debt issues, although these proportions may change as national economic conditions change.

(b) The portfolio will be managed according to the "efficient market hypothesis" discussed earlier. The following procedures will be used. *(i)* A minimum of two reviews of the AAEA investment portfolio will be conducted each year as part of the responsibility of the Finance Committee. These reviews and resulting actions will be completed before each regular meeting of the AAEA Board of Directors.

(ii) A portfolio subcommittee of the Finance Committee, consisting of two members of that committee plus the secretary-treasurer, will undertake an initial review and analysis. As part of this process at least one other set of professional opinions concerning the portfolio will be obtained besides that of the brokerage firm currently holding the AAEA portfolio. The subcommittee will be encouraged to use the expertise of selected AAEA members and/or facilities of their employers as they deem necessary and appropriate.

(iii) The portfolio committee will present a sum-

mary of their analysis and recommendations to all members of the Finance Committee for review and discussion. The Finance Committee, as a whole, will recommend specific actions on portfolio changes including specific risk management procedures to all AAEA Board members. Both the recommendations and explanatory materials will be forwarded to all Board members.

(iv) Changes in the portfolio will be authorized with the agreement of two-thirds of AAEA Board members. If such approval is not received, no changes in the portfolio will occur. Board members wishing to indicate a negative response must notify the chairman of the Finance Committee within two weeks after receiving a recommendation; otherwise, a positive response to the recommendation will be assumed.

(v) Review of individual transactions made with respect to the investment portfolio will be an agenda item for AAEA Board meetings. Discussion of procedures followed by the Finance Committee, mechanisms used to review the portfolio, and specific target objectives for managing the portfolio will be appropriate items for discussion.

Prepared by the Finance Committee
B. F. Stanton, Chairman

Report of Tellers Committee

Ballots received from the secretary-treasurer of the AAEA were counted in accordance with the bylaws of the AAEA to preserve the secrecy of the ballots. Candidates receiving the largest number of votes were: Bernard F. Stanton for president-elect, and G. Edward Schuh and Joseph D. Coffey for directors.

Harry H. Hall
Lynn W. Robbins

Report of the Editor

When I became editor three years ago, a committee to evaluate the *Journal* had just completed its report. They made seven recommendations to the editor, and in the first part of my report I summarize the responses made to the recommendations. I also comment on certain premises (views about the *Journal*) that served as a basis for the recommendations. I conclude with a discussion of the current status of the *Journal*.

Three of the evaluation committee's recommendations related to the mechanics of journal operation such as making authors anonymous in the review process. These were helpful suggestions, and it was relatively easy to respond to them. Another recommendation suggested that review articles be commissioned. Since the AAEA is publishing a three-volume literature review, I commissioned only one such article. It appears in the August 1977 issue.

Three other recommendations followed from views that articles in the *Journal* are usually methodological in nature and that few policy-oriented papers are published. The committee suggested that articles include only "essential" mathematics and that the editors instruct authors to focus on the policy implications of their work. In addition, articles dealing with problems, ideas, and issues in a literary style should be given full consideration. Nonmathematical essays are, of course, welcomed by the editor, and we have worked to eliminate redundant and unnecessary mathematics. While it is difficult to force authors to highlight the policy implications of their analyses, the editorial staff has stressed this point on many occasions.

The implementation of these recommendations has probably been beneficial, though readers must judge whether observable changes have occurred. However, in my view, the general premises that served as a basis for the recommendations are misleading. Moreover, the recommendations involve cosmetic-type changes to submitted manuscripts. Thus, the potential benefits of implementing the recommendations could be exaggerated.

Perhaps the greatest myth perpetuated by the evaluation report is that the *Journal*'s contents are highly methodological. Related to this myth is the charge that current and past editors select only methodological papers for publication. Just the opposite is nearer the truth. Our profession is applications oriented; the majority of manuscripts received are empirical applications; and the material published is mainly of an applied character. Those who doubt this view should examine the entire contents of the *Journal* for the past several years. I also invite comparison with the *American Economic Review* or other leading economics journals. I believe that such examinations will show that the *Journal* is an applied journal both in a relative and in an absolute sense.

The editors—past and present—have been open to diversity in submissions. For example, in 1976–77, seven manuscripts directly related to teaching were submitted. Four were accepted for publication, an acceptance rate substantially above the average for all manuscripts. Varden Fuller in his 1971 report and Max Langham and Leo Polopolus in 1974 admitted to similar "biases" toward contributions in extension, teaching, and business. This long-time emphasis by editors on breadth in the *Journal*, however, does not stimulate much response in terms of submissions.

Another misleading premise of the evaluation report is that published articles do not address current

policy issues. Again, I invite review of the *Journal*'s contents. One will find papers on many current policy issues such as energy, land use, rural labor, price stabilization, and dairy imports. A more accurate criticism is that many published articles are not useful for public or private decision making nor do they always provide useful ideas or insights. The real challenge is how to stimulate more manuscripts that have direct decision-making applications. If received, editors would be delighted to publish them.

Still another misconception is that a large number of high quality papers are rejected. While editors sometimes make incorrect decisions, the material published is largely determined by what is submitted. Thus, the major determinant of the *Journal*'s quality is the quality of submissions. Put another way, the actions of the editor—in selecting manuscripts, in screening out redundant mathematics, in issuing invitations, in being open to essays, and so forth—are not the major determinants of the *Journal*'s quality. As a necessary condition, authors must contribute the thought, time, and effort to produce high quality manuscripts. This is a challenge to the entire profession, not just to the editor.

A policy implication of the foregoing is that the marginal returns in terms of quality to making further evaluations of the *Journal*, making changes in the *Journal*'s format, or in cosmetic editing of manuscripts are not large. Rather, a more interesting question is: can the AAEA do more to stimulate high quality research and writing on topics of special relevance to agricultural economists?

Turning to the routine duties of your editor for the past year, I continued to devote considerable time to the business management of the *Journal*. This included serving on an ad hoc page charge committee (reported elsewhere), granting numerous permissions to reprint material, as well as other correspondence. The editors-elect, V. James Rhodes and Stanley R. Johnson, visited Cornell in April to discuss the transfer of the editorship. The new printing contract is working reasonably well, and the *Journal* is living within the budget.

Table 1. New Submissions, Manuscripts Published, and Publication Rate, 1967/68–1976/77

Year	Number of New Submissions[a]	Number of Manuscripts Published	Publication Rate (%)
1967–68	212	100	47
1968–69	268	105	39
1969–70	249	95	38
1970–71	250	96	38
1971–72	264	96	36
1972–73	263	90	34
1973–74	285	98	34
1974–75	332	91	27
1975–76	263	92	35
1976–77	311	90	29

[a] Excludes proceedings papers and book reviews.

In 1976–77, 311 new submissions were received, and 90 refereed articles and notes were published in 1977 (table 1). In addition, five folders were forwarded to the new editor with a recommendation to publish in 1978. These were manuscripts that could have been published in 1977 except for a budget constraint. This is the first time in my editorship that the budget has been a constraint on publication, but it is too early to tell whether a backlog of manuscripts will build up. In my three-year editorship, 906 new manuscripts were received, and 273 (30%) were published. This does not mean that 70% of the submissions were rejected, but often the revisions required are so large that authors choose not to make them.

The number of manuscripts published per year has ranged from 90 to 105 over the past 10 years (table 1). Typically, 90 to 95 refereed pieces are published. However, the total number of pages per

Table 2. Allocation of Pages to Alternate Types of Material

Year	Refereed Papers: Articles	Refereed Papers: Notes[a]	Proceedings Papers	Misc.[b]	Proportion Pages Refereed	Total Pages (No.)
	----------	----------	---------- % ----------	----------	----------	
1970	41.2	14.3	30.8	13.7	55.5	879
1971	37.4	17.1	29.9	15.6	54.5	956
1972	28.7	22.7	32.3	16.3	51.4	1,013[d]
1973	19.3	29.2	30.8	20.8[c]	48.5	1,073[c]
1974	22.2	30.2	32.8	14.8	52.4	1,264
1975	42.1	14.4	29.4	14.0	56.5	1,033
1976	42.4	16.9	25.6	15.1	59.3	1,071[d]
1977	36.8	19.3	32.0	11.9	56.1	1,164

[a] In 1970–74, notes includes short articles and communications.
[b] Miscellaneous includes book reviews, books received, news-type material, contributed papers abstracts, AAEA reports and minutes, and an index (pages for ads not counted in totals).
[c] A 64-page teaching workshop was published as part II of the November 1973 issue.
[d] Does not include *Handbook-Directory*.

Table 3. Reviewers, June 1976 to June 1977

Dale W. Adams
Richard M. Adams
Masakatsu Akino
P. G. Allen
Jock R. Anderson
Raymond L. Anderson
Robert C. Anderson
Terry L. Anderson
Emil Attanasi
Emerson M. Babb
Mark Bailey
Robert Bain
C. B. Baker
Malcolm D. Bale
John L. Baritelle
Randolph Barker
Paul W. Barkley
Terry Barr
Richard L. Barrows
Peter J. Barry
C. Phillip Baumel
Lloyd Bender
Carlos A. Benito
Richard F. Bieker
Arlo W. Biere
Hans P. Binswanger
Leo V. Blakley
David Blandford
Michael Boehlje
William T. Boehm
James T. Bonnen
Anthony Bottomley
Jean-Marc Boussard
Wayne A. Boutwell
John R. Brake
George E. Brandow
George L. Brinkman
S. M. Brock
Ray F. Brokken
David W. Brown
William G. Brown
W. Keith Bryant
J. Bruce Bullock
Oscar R. Burt
Rueben C. Buse
Boyd Buxton
Derek R. Byerlee
Gerald Campbell
Keith Campbell
W. V. Chandler
Thomas A. Carlin
Gerald A. Carlson
Hoy F. Carman
Ian D. Carruthers
Kenneth L. Casavant
George L. Casler
James C. Cato
Frank J. Cesario
Dean Chen
Wen S. Chern
Dennis Chinn
Laurits R. Christensen
Kenneth C. Clayton
Willard W. Cochrane
Arthur L. Coffing
Edward Cohn
Robert I. Coltrane
Frank S. Conklin
Larry J. Connor
Sam M. Cordes
James Cothern
Warren C. Couvillion
Charles O. Crawford
Richard J. Crom
William A. Cromarty
Pierre R. Crosson
James A. Crutchfield
Ronald G. Cummings
Martin Currie
Stan Daberkow
Dale C. Dahl
Dana G. Dalrymple
Raymond Daniel
John C. Day
Brady J. Deaton
J. Larry Deaton
David L. Debertin
Alain deJanvry
Carleton C. Dennis
Gary T. Devino
Pritam S. Dhillon
John L. Dillon
Gerald A. Doeksen
Otto C. Doering III
G. F. Donaldson
Ronald Dorf
Peter P. Dorner
Norbert A. Dorow
H. Evan Drummond
K. William Easter
Clark Edwards
William F. Edwards
Alvin C. Egbert
Carl K. Eicher
Vernon Eidman
Doyle A. Eiler
Thomas Elam
Joachim Elterich
Robert D. Emerson
Donald J. Epp
Robert Evenson
Walter P. Falcon
R. W. Farebrother
W. S. Farris
Jerry A. Fedeler
Gershon Feder
Richard S. Fenwick
John N. Ferris
Robert Finley
Loyd K. Fischer
Lehman B. Fletcher
Raymond J. Folwell
D. Lynn Forster
Philip W. Foster
Austin S. Fox
John R. Franzmann
J. W. Freebairn
Ben C. French
R. J. Freund
Conrad F. Fritsch
Peter A. Frost
Stephen Fuller
Mason Gaffney
Hazen F. Gale
Paul Gallagher
B. Delworth Gardner
Bruce L. Gardner
Charles B. Garrison
Peter V. Garrod
Gordon Gemmill
Eugene E. Gerke
E. Bruce Godfrey
Robert S. Golden
William W. Goldsmith
Frank M. Goode
John R. Gordon
Richard L. Gordon
Louis Goreux
Truman Graf
Roger W. Gray
John W. Green
Richard Green
R. Clyde Greer
Keith Griffin
Wade L. Griffin
Thomas A. Grigalunas
James W. Gruebele
J. W. B. Guise
Russell L. Gum
Walter Haessel
Harold Halcrow
Milton C. Hallberg
Albert N. Halter
Robert Halvorsen
James L. Hamilton
Jerome W. Hammond
Timothy M. Hammonds
Charles R. Handy
John B. Hardaker
Ian W. Hardie
Wm. E. Hardy, Jr.
David H. Harrington
Duane G. Harris
Joseph Havlicek
Michael Hay
Yujiro Hayami
Marvin Hayenga
Peter B. R. Hazell
J. C. Headley
Thomas Heberlein
Dale M. Heien
Richard C. Heifner
Peter G. Helmberger
Dennis Henderson
Robert Herdt
William Mcd. Herr
W. Whitney Hicks
L. Dean Hiebert
Lowell D. Hill
Jimmye S. Hillman
Fred K. Hines
James C. Hite
Irving J. Hoch
Eithan Hochman
David W. Holland
James Holt
James P. Houck
Howard Howe
Richard Howitt
John Hubbard
Wallace E. Huffman
Robert M. Hutchens
David N. Hyman
John E. Ikerd

Table 3, cont.

Craig L. Infanger
Geoffrey Jackson
Ray D. Jackson
Robert E. Jacobson
J. Dean Jansma
Harald R. Jensen
Edward V. Jesse
Marc A. Johnson
Paul R. Johnson
R. Bruce Johnson
Ralph D. Johnson
Stanley R. Johnson
Stewart Johnson
William Johnson
Larry D. Jones
Lonnie L. Jones
Robert F. Jones
William O. Jones
Richard E. Just
John Kadlec
Don Kanel
Martin T. Katzman
Earl W. Kehrberg
Maurice M. Kelso
John O. S. Kennedy
Richard A. King
Yoav Kislev
Robert Klepper
James B. Kliebenstein
Darwin Klingman
Dave Knapp
Peter Knight
Ronald D. Knutson
T. A. Kofi
William E. Kost
Marvin W. Kottke
George W. Kromer
Robert G. Kuller
George W. Ladd
Max R. Langham
Ralph Lattimore
Lawrence J. Lau
John E. Lee, Jr.
T. C. Lee
Warren F. Lee
C. E. Lemke
Raymond M. Leuthold
Donald Ray Levi
Steve Levine
Lawrence W. Libby
Charles Liu
Edna Loehman
Burl Long
William Lord
Clifton B. Luttrell
Donald W. Lybecker
Alexander F. McCalla
Bennett T. McCallum
Bruce McCarl
Kenneth E. McConnell
James W. McFarland
Melville L. McMillan
Donald MacLaren
G. S. Maddala
J. Patrick Madden
Thomas A. Mahoney
Alden C. Manchester
Lester V. Manderscheid
Jitendar S. Mann
Harry P. Mapp
J. Rod Martin
Larry J. Martin
R. Thomas Martin
William E. Martin
Gene A. Mathia
H. A. Meier
K. D. Meilke
Joseph C. Meisner
Emanuel Melichar
Thomas A. Miller
Robert A. Milligan
Roger Montgomery
C. V. Moore
Larry C. Morgan
E. R. Moscardi
Mohinder S. Mudahar
W. F. Mueller
Jürgen Müller
Wesley Musser
J. H. Mutti
Lester H. Myers
James J. Naive
Glenn L. Nelson
Kenneth E. Nelson
John W. Nixon
Richard B. Norgaard
Ronald M. North
C. W. O'Connor
J. Frank O'Connor
Walter Y. Oi
Ronald A. Oliveria
Desmond O'Rourke
Frank H. Osterhoudt
Charles E. Overton
Don Paarlberg
E. C. Pasour, Jr.
George F. Patrick
Arnold A. Paulsen
Anne E. Peck
Neil H. Pelsue
J. B. Penn
John B. Penson, Jr.
Dwight H. Perkins
R. K. Perrin
Willis L. Peterson
Ronald R. Piggott
Per Pinstrup-Andersen
Rulon D. Pope
John P. Powelson
Mark J. Powers
Anthony A. Prato
David W. Price
Wayne D. Purcell
Malcom J. Purvis
L. C. Quance
Ronald E. Raikes
Alan Randall
Norman Rask
Gordon C. Rausser
Daryll E. Ray
Gerald Rector
R. Bruce Rettig
Shlomo Reutlinger
Courtney Riordan
Warren Robinson
Lindon J. Robison
Terry Roe
Gordon Rose
James Roush
Mary Ryan
Gian Sahota
Larry E. Salathe
P. L. Scandizzo
William A. Schaffer
Con H. Schallau
Gerald Schluter
A. Allan Schmid
Andrew Schmitz
L. D. Schnake
Kenneth Schneeberger
Lee F. Schrader
Ronald A. Schrimper
G. Edward Schuh
Wayne A. Schutjer
John T. Scott, Jr.
James A. Seagraves
Stanley K. Seaver
W. D. Seitz
Gerald L. Setter
Benjamin Sexauer
Leonard Shabman
Ronald E. Shaffer
Mathew D. Shane
Jerry A. Sharples
C. Richard Shumway
Melvin D. Skold
Rudie W. Slaughter
Leslie Small
Dennis K. Smith
Steven T. Sonka
Stephen H. Sosnick
Robert G. F. Spitze
Joe B. Stevens
Robert D. Stevens
Thomas F. Stinson
Richard L. Stroup
Abraham Subotnik
Earl R. Swanson
James Sweeney
H. Talpaz
C. Robert Taylor
Robert W. Taylor
Lester D. Telser
Daymon Thatch
William C. Thiesenhusen
Robert L. Thompson
Stanley Thompson
Daniel S. Tilley
C. Peter Timmer
Robert Tollison
Robert J. Tosterud
W. Bruce Traill
Peter Tryfos
Stephen J. Turnovsky
Luther G. Tweeten
Fred H. Tyner
Martin Upton
Peter J. Urban
Noel D. Uri
Jan H. van der Veen
James C. Wade
John J. Waelti
Harold Walker
L. T. Wallace

Table 3, cont.

Forrest Walters	Morris D. Whitaker	Don Winkelmann
Benjamin Ward	Fred C. White	Larry J. Wipf
Ronald W. Ward	Norman K. Whittlesey	Michael E. Wirth
T. K. Warley	Thomas B. Wiens	John Wise
Thomas F. Weaver	Maurice Wilkinson	Abner Womack
Frederick J. Wells	Cleve E. Willis	W. Fred Woods
Robert C. Wells	Robert J. Willis	Bernard Yon
Delane E. Welsch	Walter J. Wills	Russell C. Youmans
Kelso L. Wessel	Ewen M. Wilson	

volume has increased about 10% from 1971 to 1976 (table 2). I doubt that this was a conscious decision, but I hope that the AAEA's budget is sufficiently flexible to absorb additional modest growth if acceptable papers become available.

Of the total pages published per year, about 55% are devoted to reviewed papers, 30% to proceedings papers, and 15% to miscellaneous material (table 2). In essence, the editor and the book review editor have direct control over about 60% to 65% of the material in the *Journal*. Invited proceedings papers, abstracts of contributed papers, committee reports, and other miscellaneous material constitute the remainder. Whether or not this balance is appropriate is a matter of judgment. I recommend that from time to time the AAEA Board undertake a conscious review of the trade-off between invited and reviewed papers. Obviously, this becomes more important if the budget should become a constraint to the prompt publication of high quality, refereed manuscripts.

Jim Rhodes and Stan Johnson have my best wishes as they assume the duties of the editorship. In parting, I wish to express appreciation to a number of persons for their cooperation and assistance: the 434 reviewers (table 3), the editorial council (Martin E. Abel, Garnett Bradford, Rachel Dardis, Gene Futrell, Ray A. Goldberg, Richard C. Haidacher, Dale M. Hoover, Timothy E. Josling, Gordon A. King, Donald W. Kloth, Ronald Lacewell, Wyn F. Owen, Darrell Plaunt, Robert Raunikar, Herbert H. Stoevener, and Finis Welch), the *Journal* secretary, Ruth Mezei, the assistant editor, Nancy Larrabee, the book review editor, Francis Walker, and my associates, Richard Boisvert and Donald Freebairn. I also want to acknowledge the cooperation of my Cornell colleagues as I borrowed their secretaries and asked for their assistance in identifying reviewers. Finally, I wish to express my gratitude to the members and to the Board of the AAEA for the opportunity to serve as editor.

William G. Tomek, editor

Report of the Awards Committee

The Awards Committee this year helped to develop a statement for a Distinguished Policy Contribution Award (published in the November 1977 issue), a recommendation on the question of restricting nominees for awards to AAEA members (appendix), and a nomination document for the Browning Award. As part of its regular duties, it conducted the various competitions and selected the winners.

The delays and frustrations associated with the weather and postal services were much greater than in previous years. In consequence, substantial extra costs were incurred by departments in duplicating lost or undelivered documents, and deadlines had to be extended. Problems arose with both the master's and doctoral awards because one or more members of the committee had served as major professor for a thesis in the competition. Such committee members abstained from voting on that entry, but this in turn distorted the outcome. Supplemental judges were used and rereading of the top six entries was required to resolve one such situation. However, no change is recommended since when members are appointed to a committee for a three-year term, there is no way of knowing what entries will be submitted.

Suggestions made by members for improvement can and will be incorporated into the operational framework for next year. The Awards Committee structure works smoothly and functions well. Cooperation from committee members is excellent. Their contribution to the AAEA and through it to those who are recognized is indeed great and is made without fanfare or public acclaim.

The AAEA award winners for 1977 appear below.

Distinguished Extension Program

Less than ten years. **Otto C. Doering III,** associate professor, Purdue University.
Ten or more years. **Phillip C. Baumel,** professor, Iowa State University.

Distinguished Undergraduate Teaching

Less than ten years. **David E. Hahn,** associate professor, Ohio State University.
Ten or more years. **Milton M. Snodgrass,** professor, New Mexico State University.

Outstanding Master's Degree Program

Douglas C. Holliday. "An Analysis of Economic Relationships and Performance in the Canadian Broiler Industry." University of Guelph (adviser: L. J. Martin).
Andrew M. Novakovic. "The Impact of Imports of Manufactured Milk Products on the United States Dairy Industry." Purdue University (adviser: Robert L. Thompson).
Eugene S. Rosera. "The Economic Impacts of Industrialization on a Rural Louisiana Economy: La Salle Parish." Louisiana State University (adviser: L. J. Guedry).

Outstanding Doctoral Degree Program

Nancy E. Bockstael. "Analysis of Investment Behavior and Price Determination: Analytical Input for the Formation of Policy in the Fisheries." University of Rhode Island (adviser: Darrell L. Hueth).
Geraldo S. De Camargo Barros. "Asking Wages, Market Wages, and the Off-Farm Supply by Farm Operators." North Carolina State University (coadvisers: Walter J. Wessels and Dale M. Hoover).
Bruce L. Dixon. "A Stochastic Control Approach to Harvest Scheduling in a National Forest." University of California, Davis (adviser: Richard E. Howitt).

Quality of Research Discovery

J. A. Edwards, K. C. Gibbs, L. J. Guedry, and H. H. Stoevener. *The Demand for Non-Unique Outdoor Recreational Services: Methodological Issues.* Oregon Agr. Exp. Sta. Techn. Bull. 133, May 1976.
Ronald W. Ward. *The Economics of Florida's FCOJ Imports and Exports: An Econometric Study.* Florida Department of Citrus, Econ. Res. Dep. Rep. 76-1, Aug. 1976.
Honorable mention: Oscar R. Burt. "Ground Water Management and Surface Water Development for Irrigation." *Economic Modeling for Water Policy Evaluation,* pp. 75–95. Amsterdam: North-Holland Publishing Co., 1976.
Honorable mention: S. R. Thompson, D. A. Eller, and O. D. Forker. "An Econometric Analysis of Sales Response to Generic Milk Advertising in New York State." *Search-Agriculture,* vol. 6, no. 3. Cornell University Agr. Exp. Sta., 1976.

Quality of Communication

Wallace Barr et al. *Your Food.* National Public Policy Education Committee Publ. No. 5, Ohio State University Cooperative Extension Service, 1976.
W. W. Cochrane and Mary E. Ryan. *American Farm Policy 1948–1973.* Minneapolis: University of Minnesota Press, 1976.
Honorable mention: John G. McNeely and Ronald D. Lacewell. *Flood Plains Management.* Texas A&M University Agr. Exp. Sta. B-1166, Nov. 1976.
Honorable mention: George F. Smith and M. B. Badenhop. *An Economic Evaluation of Environmental Quality: Opportunity Costs of Channelization and Land Use Change in The Floodplain of the Obion-Forked Deer River Basin of West Tennessee.* University of Tennessee Agr. Exp. Sta. Bull. 522, Dec. 1975.

Publication of Enduring Quality

Karl A. Fox. *Econometric Analysis for Public Policy.* Ames: Iowa State University Press, 1958.

Outstanding Journal Article

Per Pinstrup-Andersen, Norha Ruiz de Londoño, and Edward Hoover. "The Impact of Increasing Food Supply on Human Nutrition: Implications for Commodity Priorities in Agricultural Research and Policy." *Amer. J. Agr. Econ.* 58 (1976):131–42.

Appendix

The Awards Committee was asked whether the AAEA's awards should be restricted to AAEA members. Only one member of the committee suggested without qualification that competitions be restricted to AAEA members. It is, therefore, the recommendation of the committee that the AAEA should not restrict its awards to members only.

The AAEA must first decide the basic issue of why it has an awards program—to encourage and recognize outstanding contributions by agricultural economists or by AAEA members. If it is the former, the question is answered, and contestants would not have to be AAEA members. If it is the latter, obviously those who are not current AAEA members would not qualify. This might cause difficulty where a person had his membership cancelled for nonpayment of dues by a specific date. Even then contestants for the Outstanding Master's Program and Outstanding Doctoral Program do not submit their own thesis in competition and do not even know that has happened and should not, therefore, be required to be AAEA members; otherwise, departments might be forced to submit their fourth or fifth best thesis.

While there is a valid argument that persons nominated for the other awards should be interested in and actively participating in the profession, it is more than counterbalanced by the realization that all agricultural economists as well as society at large benefit from these outstanding contributions and recognition of them.

The majority of the Awards Committee agree. Therefore, the recommendation of the committee is that the AAEA recognize outstanding contributions

within the profession rather than only within the AAEA.

A. Gordon Ball, chairman

Report of the Postwar Literature Review Committee

Volume I has been available for purchase by AAEA members from the AAEA and by others from the University of Minnesota Press since December 1976. All the material for volume II is in the hands of the Press, the copy editing is complete, and almost all the corrected galley proofs have been returned by the authors. The expected publication date is November 1977. Volume II is entitled *Quantitative Methods in Agricultural and Resource Economics, 1940s to 1970s*. It was edited by George Judge, Richard Day, S. R. Johnson, Gordon Rausser, and Lee Martin. The table of contents is reported in the December 1976 issue of the *Journal*.

When completed, volume III will be entitled *Economics of Welfare, Development and Natural Resources, 1940s to 1970s*, edited by Lee Martin. The table of contents will be approximately as follows.

I. "Economics of Rural Poverty" by Lee Bawden and Keith Bryant.
II. Rural People, Communities and Regions, George Tolley, coordinator
"Economic Bases for Growth" by Clark Edwards.
"Rural Development: Problems and Prospects" by Dean Jansma, Hays Gamble, Pat Madden, and Rex Warland.
"Population Distribution: Migration and Settlement Patterns" by Marian Clawson and P. Graves.
III. Agriculture in Economic Development
"Africa" by Carl Eicher.
"Asia" by John Mellor.
"Latin America" by Edward Schuh.
IV. "Natural Resource Economics, 1946–1975" by Emery Castle, Maurice Kelso, Joe Stevens, and H. H. Stoevener.
V. "Philosophic Foundations of Agricultural Economic Thought" by Glenn Johnson.
VI. "Organization and Performance of Agricultural Markets" by Peter Helmberger, Gerald Campbell, and William Dobson.

The surveys of "Natural Resource Economics" and "Rural Development" have reached us in final form. The Edwards survey is being prepared in final form at the present time. We expect first drafts from Glenn Johnson, Carl Eicher, and Edward Schuh in the next three or four weeks. We have been promised the other four first drafts within the next three months or earlier. We anticipate having all the material to the University of Minnesota Press by March 1978 or perhaps a little earlier. That would yield a publication date of September or October 1978.

Lee R. Martin, chairman

Report of Committee on Publication of Postwar Literature Review

An agreement dated July 1976 between the AAEA and the University of Minnesota Press for publication of volume II of the Review was signed. Terms of the agreement were essentially the same as for volume I. Volume II is scheduled for delivery in December 1977.

Sales of volume I as of 15 June 1976 amount to 433 copies, of which 201 went to AAEA members. An additional 50 copies were distributed for reviews. The Press has taken steps to expand sales outside the United States, and the AAEA has sent material to members informing them of the special purchase price. Royalty on the above nonmember sales amounts to $1,160 (232 copies × $5.00) and thus recovers part of the AAEA $7,500 grant in aid for publication.

The committee will negotiate terms of an agreement for volume III after its acceptance by the Press and will make recommendations to the Board.

Emerson M. Babb, chairman

Report of Literature Retrieval Committee

The Literature Retrieval Committee held a breakfast meeting in San Diego on 1 August 1977. Planning and other activities have been carried out through correspondence and telephone, while several committee members have talked with Mr. Ogden and Miss Kenyon at the demonstrations they have been giving at major meetings of agricultural economics organizations. We believe that the demonstrations have been helpful in encouraging agricultural economists to send their publications, with abstracts, to the American Agricultural Economics Documentation Center, although much remains to be done by members of the committee and the university cooperators.

Members of the committee have been active in securing interested cooperators at the land grant universities and other institutions. This is a task that requires continuing attention. Our greatest need is to make agricultural economists aware of the availability and usefulness of the literature retrieval system. Committee members and Documentation Center staff must give emphasis to this effort. We also urge members of the Executive Board to make the profession more aware of this resource.

The following points on the first nine months of the operation of the Documentation Center under

the new arrangement deserve special mention. (*a*) The Center is currently adding citations to the information base at the rate of 2,400 a year, compared with 800 a year in prior years. (*b*) The Center staff and the Literature Retrieval Committee are investigating the possibilities of closer cooperation with WAERSA (World Agricultural Economic and Rural Sociology Abstracts). (*c*) Cooperative arrangements with the National Agricultural Library have reduced duplication and made the Documentation Center responsible for accessioning articles in all U.S. and Canadian agricultural economics journals and all Economic Research Service publications. (*d*) Substantial economies have been made in the cost of each entry in the data base. The proposed AAEA budget for next year is basically the same as for this year. However, Director Kenyon urges that the Board consider adding $12,000 to this budget to hire an additional person to assist in indexing and terminal operation.

The committee recommends that the Literature Retrieval Committee be extended as presently constituted for another year, that the Executive Committee approve the budget as submitted and give serious consideration to an additional sum of $12,000 to hire an additional person, and that the Executive Board endorse further explorations with the Canadian groups and WAERSA to achieve further coordination of the information retrieval programs.

Wayne D. Rasmussen, chairman

Report of the Professional Activities Committee

This committee has held one lengthy meeting and used the mails to conduct two substantive pieces of business during 1976–77. In midwinter the committee prepared a policy statement regarding the AAEA's posture toward sponsoring and/or endorsing seminars, colloquia, and symposia. The statement was returned for amendment before being adopted by the Board. The committee also began inquiries into the possible use of the National Science Foundation's (NSF) "Science for Citizens" program, in which the NSF underwrites activities that provide opportunity to increase public awareness of the impact of scientific achievement on the welfare of U.S. society. These inquiries are continuing.

At a two-day meeting in April, the committee continued its deliberations on the selective and collective goods offered by the AAEA, the organization of the AAEA, and the future configuration of the AAEA. The committee also took leadership in preparing the "AAEA—Issues and Answers" session for the 1977 annual meeting.

The organization's future is intimately bound up in its capacity to deliver goods and services that are useful to the membership. An element of disquiet seems to pervade the AAEA, so it can be inferred that the AAEA is not acting to capacity. A strategy to cope with disquiet should be developed. This strategy should recognize the changing nature of the profession and of the individual professional. It should include elements of retraining, a new configuration for publications, and a new base for AAEA membership. Although these dates are subject to modification, this committee feels that by 1980 the AAEA should have an updated and responsive set of publications and a retraining program available to agricultural economists. By this date, the AAEA should also have a policy of broadening membership to include more undergraduate students and more professionals who currently work in occupations outside the federal government, the land grant system, and the major private firms.

The AAEA should work toward reorganization by 1985. The reorganization should make a specific place for the several subdisciplines now recognized within agricultural economics. It should also have a permanent secretariat and expanded involvement of the president-elect in program planning.

At the request of President Farrell and President-Elect Hildreth, the committee examined the role and interrelationships among several standing and ad hoc committees. We recommend that the visiting lecturer program and committee be discontinued unless a suitable source of funding can be found to sponsor its intended activities; that a program committee be established to assist in planning the content of the annual meeting; that the Professional Activities Committee have one of its members enjoy joint membership on the Alternative Publications Committee; and that the Professional Activities Committee have one of its members enjoy joint membership on the Industry Affairs Committee.

The committee feels that a number of significant issues need in-depth study by the AAEA and its membership. This is not easily accomplished. One method of attaining this goal is by publishing analyses of issues in the *Journal* or in some other AAEA publication. To that end, we recommend that the president and the editor collaborate in commissioning articles dealing with (*a*) accreditation and certification of agricultural economists; (*b*) the AAEA: a federation or a guild?; (*c*) keeping up with the expanding boundaries of economic knowledge; and (*d*) the complexity of present information systems.

The committee feels that many issues surrounding the quantity and quality of individuals in the profession could be solved in the teaching departments that now train the nation's agricultural economists. The AAEA should go on record as encouraging chairpersons and heads of these departments to become more insistent about updating the skills of their staff and integrating the packages of services they provide for both undergraduate and graduate students.

The next year will see intensive committee involvement in the Science for Citizens program, retraining and updating of agricultural economists, and alternative forms of organization for AAEA membership.

Paul W. Barkley, chairman

Report of the Economic Statistics Committee

The terms of Harry Trelogan, Quentin West, and James Hildreth expired, and they were replaced on the committee by Arlo Biere, Kansas State University, Howard Hjort, director of Agricultural Economics, USDA, and Norman Whittlesey, Washington State University.

The principal activity of the committee during the past year was the sponsorship of the Agricultural and Rural Data Workshop in conjunction with the Statistical Reporting Service, Economic Research Service, and Agricultural Marketing Service of the U.S. Department of Agriculture. Held 4–6 May 1977 in Washington, D.C., the workshop brought together data producers and users to develop suggestions and recommendations for use by agencies responsible for improving data and data series. The workshop was comprised of two series.

The topic for series A was price reporting and capacity of the food and fiber system (William Kibler, leader). Team leaders were James Bonnen, Michigan State University (price reporting), and Earl Swanson, University of Illinois (capacity of the food and fiber system).

The topics for series B were indicators of economic well-being of people engaged in farming and farm and rural employment data (Gaylord Worden, leader). Team leaders were Luther Tweeten, Oklahoma State University (data for indicators of well-being of people engaged in farming), James Holt, Pennsylvania State University (definition and measurement of farm employment), and Clark Edwards, Economic Research Service, USDA (employment data for rural development research and policy).

The workshop was well attended; the discussion was lively and constructive. Papers were revised after the workshop. Series A papers are being published by the Statistical Reporting Service (Bill Kibler, liaison) and the series B papers by the Economic Research Service (Ed Reinsel, liaison). In addition, a seminar is being held at the San Diego meeting to summarize the proceedings of the workshop. In addition to revising papers presented at the workshop, each team is preparing a plan of action (two to three pages in length) to use as a concise statement for administrators and policy makers in appraising action to implement operationally the recommendations from the papers.

The Economic Statistics Committee met after the workshop. In addition to laying the groundwork for publication of the workshop proceedings, the committee recommends several actions requiring approval of the Executive Board of the AAEA.

(*a*) The committee requests the Executive Board to approve the commissioning of two task forces to lay out the conceptual framework and operational guidelines for implementation on the following respective subjects: the economic value of statistical information (Bill Kibler will arrange for a task force to carry out the project based on suggestions from the Economic Statistics Committee) and measuring agricultural productivity (Luther Tweeten will arrange for a task force to carry out the project based on suggestions from the Economic Statistics Committee). Personnel from the USDA as well as "outsiders" will be included on these task forces.

(*b*) The Economic Statistics Committee requests that the Executive Board empower the committee to appoint an ad hoc task force on "Survey of Agricultural and Food Outlook." The purpose of the task force is to investigate the feasibility of a periodic survey of agricultural and food outlook specialists to obtain their forecasts for agricultural prices, production, etc., and to disseminate and evaluate the results in a suitable manner. The task force is to design a system to accomplish said tasks on a regular schedule. If the proposal of the task force appears workable and desirable in the judgment of the Economic Statistics Committee, the committee will present the proposal to the Executive Board for approval before implementation on a regular basis.

(*c*) The committee proposes the appointment of a statistics editor for the *American Journal of Agricultural Economics*. The role of the editor would be to commission reviews of new and existing statistical data series. The reviewer would discuss the underlying concepts measured, the conceptual difficulties with the series, the collection procedure used, the period covered by the series, and the procedure for obtaining the data from the agency responsible for the data (see appendix).

(*d*) The Economic Statistics Committee recommends that an insert be made in the *Journal* publicizing the availability of the proceedings of the Agricultural and Rural Data Workshop.

Appendix

The AAEA Statistics Committee recommends that the Board of Directors of the American Agricultural Economics Association create the office of the statistics review editor of the *American Journal of Agricultural Economics*.

AAEA membership is made up predominately of applied economists with teaching, research, and extension interests in commercial agriculture and the rural economy. As applied economists, we need to be kept abreast of developments in the theoretical

and quantitative literature, and we need a vehicle for publishing such developments and their applications to commercial agriculture and the rural economy. The present structure of the *Journal* adequately performs these functions.

As applied economists, we also need to be kept abreast of developments in the statistical data system through which we take measurements on and with which we analyze commercial agriculture and the rural economy. We believe that the *Journal* is not currently serving its readers well in this regard. But, we believe that the institution of a statistics review editor of the *Journal* would rectify the situation.

Agricultural economists currently individually have the responsibility for keeping up to date with developments in the federal and state data system as well as discovering and obtaining relevant bodies of data lying outside the federal data system. Keeping abreast of the federal data system is difficult unless the individual is plugged in to a particular data collection agency, is an individual member of the Federal Statistics Users Conference (which is very expensive), or subscribes to *The Statistical Reporter* (an obscure publication of the Office of Management and Budget).

A statistics review editor could aid the membership greatly by (*a*) commissioning critical reviews of new data series or bodies of data that become available in the federal system; (*b*) commissioning critical reviews of old data series and existing bodies of data that are in the process of revision; (*c*) periodically making known new data sources that occur outside the federal system in much the same way as the book review editor currently publishes a list of publications received; and (*d*) commissioning critical reviews of new bodies of data emerging from outside the system. An example of (*a*) might have been a review of the public use tapes from the population or agricultural census. An example of (*b*) might have been a critical review of the changes in the consumer price index. Examples of (*c*) and (*d*) might have been to announce the availability of and perhaps to review the data set from the rural income maintenance experiment or data on dairy products consumption developed privately.

The work of the statistics review editor would also aid the agencies responsible for producing and maintaining the federal data system because the reviews would constitute important feedback to them.

The AAEA Statistics Committee does not visualize that the statistics review editor need have space in every issue of the *Journal*. Space should be provided only as data developments justify. The book review and the statistics review editors may be able to share the same space, working out a schedule format enabling both important books and important changes and developments in the data system to be critically reviewed as they arise.

Report of the Committee on Management, Structure, Methods, and Procedures

President Farrell appointed the above titled committee on 29 March 1977 and gave the committee an assignment with three principal objectives: (*a*) to review the management, structure, methods, and procedures of the AAEA and to then make recommendations that would enhance the quality of service to members and the efficiency in operations of the AAEA; (*b*) to examine the feasibility of establishing an AAEA executive office for program management; and (*c*) to review the performance of the secretary-treasurer during the past three to five years. The latter review is in keeping with the operating procedure prescribed for the Executive Board at the Edmonton meetings in August 1973.

The entire committee met in Minneapolis on 31 May 1977. After an extended discussion in the committee, we agreed to interpret our assignment as one with three principal focuses.

The first is to learn as much as possible about the current operation of the AAEA and to suggest useful improvements. The job here seems to be the one of learning as much as possible about each significant and identifiable activity of the AAEA. Then we need to develop some perspective on what the AAEA is locked into in the way of future activities. Finally, we need to project where future AAEA activities appear to be headed in terms of content and cost and then to suggest whatever useful improvements might be implemented. Our focus is intended to be on improving the efficiency and management of these operations, not to prioritize activities in which the AAEA should be engaged.

A second need is to examine in detail the control and decision-making framework within the AAEA. Here, the emphasis is on identifying the role played by individuals and groups, although it will also be necessary to obtain some information on performance in these various roles. At a minimum we would need to identify the role and performance of the secretary-treasurer, the AAEA board of directors, the president, the president-elect, and the past president. Our examination of the control and decision-making framework should include consideration of financial management, planning, implementation, and evaluation of services.

Finally, as quickly as feasible we need to undertake an inquiry into the possibilities for creating a managerial structure for the AAEA that would improve the effectiveness of its operation. This inquiry would likely involve an appraisal of several alternatives including but not necessarily limited to the following: (*a*) continuation of the current decentralized operation but with more specified coordination, (*b*) contracting with other professional groups, such as the American Society of Agronomy, for additional managerial services, and (*c*) establishing

a separate executive office for management either in Washington or at some alternative location.

Two subcommittees were appointed. A committee of Dick Crowder, Lou Eisgruber, Neil Harl, and John Stovall will have the responsibility for implementing the first assignment, that of learning as much as possible about the current AAEA operation. Lou Eisgruber agreed to chair this committee, which would also have the responsibility for establishing a procedure for initial inquiry into the third job.

A committee of Wally Barr, Olan Forker, Leo Polopolus and Burt Sundquist, chairman, will undertake the second assignment, that of examining the control and decision-making framework within the AAEA. One of the assignments of this second subcommittee would be the one of carrying out the required periodic evaluation of the office of the secretary-treasurer.

It was agreed that it would be desirable if the two subcommittee chairpersons or their representatives, could sit in a good part of the Board meetings at the San Diego meetings in order to become better acquainted with the current operation including the decision-making framework. President Farrell extended an invitation to do so to Eisgruber and Sundquist.

Subcommittee 1 decided to approach their assignment by asking four questions: (*a*) which individuals, groups, or institutions should be contacted, (*b*) what information should be acquired from them, (*c*) how should this information be acquired, and (*d*) when should the information be acquired?

The following suggestions were made. (*a*) Contact should be made with all AAEA committees (for this purpose a complete list of committees needs to be established, and President Farrell has agreed to provide the subcommittee with such a list) and with all members of the AAEA Executive Board as well as the secretary-treasurer, operator of the Registry of Agricultural Economists, editor of the *Journal*, individuals responsible for the organization and program of the annual meetings, the past and present AAEA presidents since 1967, all members of this committee, and others as identified.

(*b*) With respect to information that should be collected, the following was suggested. What was the specific charge of the individual or group perceived to be, what in fact did it turn out to be, what were the resources used including both human and monetary resources, what were the blockages to effective management of the activity, was the charge, in general, effectively met, to what degree was it met with respect to the adequacy of the following dimensions—information, organization, finance, and planning, was membership on the committee or board representative, what was the degree of participation on the committee or board, what are your suggestions for improvement of management, control, accountability, etc., who is (was) responsible for budget and membership of this group?

(*c*) With respect to the question of how the information should be collected, a personal or telephone interview was suggested for AAEA presidents since 1967. For the twenty-four past or current members of the Board of Directors, a printed questionnaire was suggested. A printed questionnaire was also suggested for use in soliciting information from AAEA committees.

(*d*) With respect to when information should be collected, we shall ask for the approval of the Executive Board of the AAEA at the San Diego meetings in order to initiate interviews as soon as possible. Approval should also be solicited at the San Diego meetings for a formal survey form to be used.

(*e*) With respect to the assignment for initiating inquiry into alternative organizational forms for AAEA management, the following suggestions were made: visit with Dave Boyne and Paul Barkley to obtain background on information which they have and select some of the more interesting professional associations and follow up with an in-depth interview on organization and style.

Subcommittee 2 suggested the following procedure for operation. Inquiries should be made relative to the role of all individuals occupying positions of significant control and decision making in the AAEA. We should try to obtain any available position description for officers and Board members. With respect to the office of secretary-treasurer, several duties of that office probably should be separated out and evaluated separately, since they are quite different functions. These include activities related to the membership function, the secretarial function, and the treasurer function. With respect to the office of secretary-treasurer particularly, it would be desirable to put together a brief historical account of the evolvement of that position in order to obtain perspective for evaluation. Some kind of a job description needs to be developed, if it is not already in existence, in order to serve as the benchmark for appraising performance of these several types of duties. Since the operation of the office of the secretary-treasurer is a very extensive one, an on-site inspection by at least a two-person subcommittee of the second subcommittee appears to be necessary. This subcommittee should also study the committee structure of the Board of Directors and of the total AAEA. This study should, however, pertain only to the issue of decision making and control.

In keeping with the time schedule suggested by President Farrell, we intend to ask approval of our procedures at the San Diego meetings, present an interim report at the 1977 winter meeting, and file a final report at the August 1978 meeting at Virginia Polytechnic Institute and State University.

Burt Sundquist, chairman

Report of the Professional Registries Committee

On 3 January 1977, the AAEA Executive Board adopted the following recommendations presented by the Professional Registries Committee in a report to the Board dated 28 December 1976: (*a*) take action declaring intent to enter into agreement with the Economic Research Service to operate a registry for agricultural economists, such agreement to be conditional upon development of a plan to generate the AAEA's share of project costs; (*b*) authorize the Professional Registries Committee to solicit commitments to fund the AAEA's share of project costs; and (*c*) approve the submission to the U.S. Department of Labor of new contract proposal to provide a final year's funding of the registry from the USDL. In addition, the Board directed the Registries Committee to continue explorations with the USDL regarding support to operate the registry beyond the period of the contract specified in (*c*) above.

On 6 January 1977, President Farrell submitted to the USDL a proposal for continuation of the USDL-AAEA demonstration project to operate and assess a computer-based employment system for agricultural economists. The extension to 15 February 1978 with additional funding in the amount of $32,800 was authorized by the USDL, and the contract modification was signed by President Farrell on 28 January 1977.

On 20 June 1977, Kenneth Farrell, Loys Mather, and David Boyne met with USDL officials in Washington. The primary purpose of the meeting was to explore possibilities for additional funding from the Department of Labor. The AAEA representatives participating in this meeting concluded that the chances are very slim for additional funding from any unit within the Department of Labor. It seems clear that we can not expect any funding from the Department of Labor as part of a financial package to support continuation of the registry beyond February 1978.

The Registries Committee has proceeded to solicit commitments to fund the AAEA's share of a joint AAEA-ERS project to operate a professional registry for agricultural economists. The 3 January 1977 report to the Board estimated the AAEA's share of joint project costs to be $14,100. The Registries Committee met on 10–11 March 1977 and agreed to map out a fund solicitation program with a minimum goal of $15,000. The following commitments have been received to date: agricultural economics departments in the United States and Canada, $7,750; Ford Foundation, $1,000; Statistical Reporting Service, $500; U.S. Agency for International Development, $5,000; Agricultural Marketing Service, $250; and Farmer Cooperative Service, indefinite. Ray Beneke and Richard Crowder are leading the business and industry effort. Beneke believes that we can reasonably expect at least $1,000 from this category.

The commitments received to date total $14,500, plus the minimum estimate of $1,000 from the business and industry category yields an expected total of $15,500. We believe that the commitments received and expected constitute a feasible financial plan for generating the AAEA's share of budget costs.

The Registries Committee in cooperation with the Employment Services Committee prepared an information flyer. Copies of this flyer were distributed to all U.S. and Canadian agricultural economics departments and to agencies of government and have been sent by the placement officer to other organizations and individuals. The Registries Committee also prepared an information leaflet entitled "Toward a Multiple Purpose Registry for Agricultural Economists." This leaflet has been used extensively in fund solicitation.

The committee recommends (*a*) authorizing the AAEA president on behalf of the AAEA to enter an agreement with the Economic Research Service to operate a Registry for Agricultural Economists (as a first step it is assumed that the president would designate an AAEA committee to work with ERS personnel in developing the terms and conditions of the agreement); (*b*) designating an AAEA committee to represent the AAEA in carrying out the terms of the agreement (it is assumed that one of the terms of the agreement would call for an AAEA committee to advise the ERS on matters related to the operation and further development of the Registry); and (*c*) authorizing the AAEA president to communicate in writing the Board's decision to consummate an agreement with the ERS to each organization that has made a commitment of funds and to confirm the amount of the commitment made by the respective organization or individual.

David Boyne, chairman

Report of the Employment Services Committee

In carrying out President Farrell's charge to the committee, the Employment Services Committee has been involved in the following activities during the past year.

U.S. Department of Labor Contracts

The committee took the leadership in developing proposals for one time extension of the AAEA-USDL contract (30 Sept. 1976 to 15 Nov. 1976) and for two project proposals obtaining an extension of time and additional funding (15 Nov. 1976 to 15 Feb. 1977 and 15 Feb. 1977 to 15 Feb. 1978). The current grant represents the final funding period with USDL for operation of the Registry. Arrangements for finance and operation of the Registry after expiration of USDL funding are being developed by the Professional Registries Committee.

Registry for Agricultural Economists

The committee is charged with supervision of the Registry. During the past year, the Registry assisted in placing ninety-six agricultural economists in either long-term or temporary job assignments. As of June, 181 job vacancies were listed and 2,192 agricultural economists were registered with the Registry. The committee commends George Vena, the placement officer, for the excellent service and leadership he is providing. The committee assisted the Professional Registries Committee in developing a bulletin board poster to provide information on the Registry and to promote its use among the profession.

Handbook-Directory

At President Farrell's request, the committee explored the feasibility of adapting the Registry for direct production of the next AAEA *Handbook-Directory* (i.e., providing camera-ready copy of biographical sketches from computer output). The committee recommends that the next *Handbook-Directory* be prepared from the Registry and that the necessary steps be taken to effect this change. These steps include making final determination of the content of biographical sketches printed in the directory and programming the necessary changes in computer format. If the Registry moves to another computer facility upon expiration of the

Table 1. Summary of Survey on Usefulness of Items in the *Handbook-Directory*, June 1977

Item	No Response	Rating: Of Little Use 1	2	3	4	Highly Useful 5	Weighted Score
Group I: Items that respondents indicated were highly useful							
Address (telephone)	3	9	11	17	33	196	4.44
Employer	5	5	5	45	75	134	4.16
Degrees held	4	10	8	34	94	119	4.09
Field of specialization	6	11	10	38	86	118	4.01
College or university attended	1	11	21	50	90	96	3.88
Year degrees granted	1	15	26	61	83	83	3.71
Nature of employment activity	16	8	16	57	74	98	3.71
Rank or title	5	16	20	67	69	92	3.69
Group II: Items that respondents indicated some ambivalence regarding usefulness							
Previous employers (3)	3	16	28	76	91	55	3.49
Type of employer	16	36	16	56	65	80	3.33
Research in process	10	23	38	72	64	62	3.28
Institution attended if no degree	7	45	47	55	57	58	3.06
Geographical list of members	11	45	39	67	54	53	2.99
Classification of members	9	40	49	71	50	50	2.98
Publications (3)	10	34	53	76	50	46	2.97
Place/year of birth	4	41	60	74	51	39	2.91
Group III: Items that respondents indicated were of little use							
Honors	7	68	53	93	30	18	2.46
Foreign languages	5	95	67	46	32	24	2.29
Geographical list of subscribers	24	87	60	53	25	20	2.10
Family status	8	114	72	51	14	10	1.92
Memberships in other associations	2	132	61	49	15	10	1.90
Listings in other directories	7	152	62	38	4	6	1.62

Note: 400 questionnaires were sent with 269 responses (67%).

Table 2. Estimated Costs for Computer Preparation of *Handbook-Directory*

One-time charges		
Direct program costs ($)		
Programmer, 1 month	1,200	
Computer	200	1,400
Joint costs of 1,000 additional persons added to the Registry ($)		
Labor ($3.50/hour)[a]	700	
Computer (60¢/registrant)	600	1,300
Charges associated with each *Handbook-Directory* edition		
Direct costs: computer output of 3,500 biographical sketches as camera-ready copy for printing ($)		
Computer	400	
Labor ($3.50/hour)[a]	28	428
Joint costs of updating biographical data of the additional 1,000 registrants prior to printing directory ($)[b]		
Labor ($3.50/hour)[a]	220	
Computer (30¢/registrant)	300	520

[a] Most of the labor charges could be absorbed by the Registry staff.
[b] Costs for updating biographical data of persons who are in the Registry for employment purposes are included in the Registry's regular budget. Their biographical data are updated each year.

USDL contract, some reprogramming will likely be required. If this reprogramming is done concurrently with the programming associated with the *Directory*, the AAEA should realize some cost savings.

Four hundred AAEA members were surveyed (67% response) to determine the opinion of members regarding content of directories. The survey results are summarized in table 1. Only a few minor changes in information collected by the Registry will be needed in order to provide the type of information the respondents considered useful in a directory. In addition, provisions can and should be made to allow each person to use the Registry for employment or directory purposes, or both. Table 2 summarizes estimated direct and joint costs. Direct one-time charges for developing the directory option are estimated at $1,400 for computer programming and related computer charges. Based on current operating costs, direct computer and labor charges are estimated to be under $450 per directory to prepare camera-ready copy for directory printing.

Annual Meeting Employment Services

As at previous annual meetings, employment services will be provided at the San Diego meeting. These services will be an extension of the year-round service provided by the Registry. The committee expresses its appreciation to the Illinois State Employment Services for equipment and supplies and to the agricultural economics departments at the Universities of Arizona, California–Berkeley, and California–Davis for labor to operate the service.

Report of the Membership Committee

Significant accomplishments during the past year include maintaining individual membership numbers at last year's levels despite higher dues and no *Handbook-Directory*, an increase in institutional members, full implementation and refinement of the target group approach to membership development, automation of membership lists of AAEA, regional associations and the Canadian Agricultural Economics Society, development and circulation of a membership information leaflet, and improved continuity of regional membership promotion by moving to joint appointment of regional and Canadian membership target group chairmen for three-year terms.

The primary challenge for the year ahead is to exploit the potential for increased membership made possible by developments of the past few years.

The Membership Committee now includes the chairmen of ten target group task forces, the AAEA secretary-treasurer, and the overall committee chairman. In addition, AAEA Executive Board member, Sylvia Lane, served as advisor to the Membership Committee and contributed a number of useful ideas.

It is difficult to relate the increased membership to specific activities of the Membership Committee or indeed to even attribute the increase to the committee's work. The effort by John Redman and his staff to contact all past members who had not rejoined and the action of the Executive Board to make membership a prerequisite to receiving certain benefits of the AAEA certainly had positive impacts on membership. Nevertheless, the efforts of the target group chairmen plus the mailing of the AAEA information leaflet to potential members hopefully had a "consciousness-raising" effect regarding membership in the AAEA.

The membership information leaflet was prepared with the assistance of the Division of Information, Economic Research Service, USDA, and distributed in a general mailing in late January. In addition, supplies of the leaflet were provided all target group chairmen.

At last year's committee meeting there was agreement that a more intensive membership development process required more information on potential membership and better methods for handling that information. Thus it was agreed that it would be highly desirable to have a computer tape and retrieval program for a master list of present and potential AAEA members. The tape could be

used to determine at any time who was a paid-up member and of which association. The retrieval program would allow sorting members and potential members according to a variety of criteria for use by the Membership Committee, by the president in making his appointments, and for reaching selected audiences with selective goods and services.

That tape has now been developed. It includes the names and other information provided on the 3,000 questionnaires returned in 1976 for the *Handbook-Directory*. In addition, the membership lists of the Southern Agricultural Economics Association, Western Agricultural Economics Association, and Canadian Agricultural Economics Society have been added to the tape and duplications eliminated. A membership list of the Northeastern Agricultural Economics Council will be provided soon and added to the tape. A software package has been developed that permits retrieval of any data on the tape for less than $5 per run. The program is operational and ready to be used. Special recognition is due William Freund of the ERS Data Services Center for contributing his time and ideas in the development of the tape and program. Emil Melichar of the Federal Reserve System provided editing services for the original tape and assisted in the development of the software package. Loyd Martin of the ERS developed information on AAEA committee assignments back through 1973, and this information has been added to the tape.

A challenge for the year ahead is to add to the usefulness of the tape by adding names of potential members of AAEA. Success in this regard will depend heavily on the effectiveness of the target group chairmen in developing a master list of potential AAEA members for their target populations. Some questions remain. A major effort and some expense will be involved in maintaining and updating the tape. This includes adding new names, identifying paid-up members, and address changes. The costs will be primarily human time and not machine costs. Another question: where should the tape be maintained? One possibility is to locate it with the secretary-treasurer and set up automatic update procedures. It could also be located with the Membership Committee chairman. Finally, it could be maintained by a private firm that specializes in such services. The tape and software are set up to be transferred easily and probably should stay with the committee chairman while the alternatives are being explored.

The relationship of the membership tape to other efforts needs to be resolved. It has been suggested that the *Handbook-Directory* could be printed from such a tape. Merger with the Employment Registry tape has also been suggested. Finally, it has been suggested that the tape could be used by the secretary-treasurer for an automated mailing list. The committee recommends that these possibilities be explored by the newly appointed Committee on AAEA Management, Structure, Methods, and Procedures. That committee was invited to have a member attend the Membership Committee meeting, 1 August 1977.

It is the view of the committee that the most effective means of increasing membership is to offer an attractive product. In that regard, the committee applauds the innovative efforts of the Board in recent years toward enhancing the variety, quality, and attractiveness of the goods and services of the AAEA. Many of these efforts will represent more potential than accomplishment, and their impact on membership will depend on the effectiveness and energy with which the potential is exploited.

The Membership Committee will meet on 1 August to develop plans and goals for the coming year, explore strategies for reaching potential members in each target group, explore means for working more effectively with the Canadian and U.S. regional associations, develop an effective plan for increasing the number of institutional members to at least 100, and develop recommendations for further use and management of the membership tape.

I wish to call the attention of the Executive Board and the AAEA membership to the unheralded, unselfish, and effective labors of the ten target group chairmen who constitute the Membership Committee. It has been my privilege and pleasure to serve with them.

John E. Lee, Jr., chairman

Report of the Industry Affairs Committee

The purpose of the Industry Affairs Committee is to promote the interest of the profession and the selective interest of industry economists within the framework of the AAEA. In line with this purpose, the committee decided that in 1977 we would work in three areas: sponsoring an industry banquet and professional sessions at the annual meetings, increasing industry membership and participation in the AAEA, and increasing interaction between industry members and the nonindustry members of the AAEA. This report includes our accomplishments for the year and recommendations for the future.

Last year the Industry Affairs Committee sent an open letter to the agricultural economics profession expressing our concerns on the education of agricultural economists for industry. Several responses were received as a result of that letter, all of them sympathetic with our concerns. However, some of the university people felt they needed help from the industry in improving their curriculums and education programs. As a result, the Industry Affairs Committee is cosponsoring an organized symposium at the annual meetings on the area of educating economists for industry. Also, we are

developing a list of industry economists who are willing to give seminars at universities to help improve university-industry interaction and information exchange. In the next few months we plan to distribute to the membership a paper outlining our ideas on curriculum needs for business careers.

Many agricultural economists are involved in forecasting, and industry economists have long expressed an interest in educational programs on forecasting. As a result, the committee has put together an organized symposium for the annual meetings that will be a forecasting methodology update.

Agriculture leadership is always of interest, and the speaker for our industry banquet will discuss a highly successful program of agricultural leadership.

Both the organized symposia and the banquet, sponsored by the Industry Affairs Committee, have industry people formally involved in the program. This is in line with our goal of increasing industry participation in the AAEA. In terms of industry membership, the Industry Affairs Committee has been working on increasing institutional membership and, as of the end of June 1977, we had signed up ten new institutional members.

Last year the committee submitted several recommendations to the Board of Directors. The prompt action taken by the Board on these recommendations was greatly appreciated. This year the Industry Affairs Committee has one recommendation: that serious consideration is given to the establishment of an award for research by a university agricultural economist that is particularly applicable to an industry problem. The Industry Affairs Committee stands ready to help with this task.

Thank you for your support.

Eugene E. Gerke, chairman

Report of the International Committee

The International Committee was reorganized by President Farrell in early 1977. The committee has engaged in two activities. The first was to assist in arranging the international events for the 1977 annual meeting and second to develop an agenda and plan of work to be carried forward during 1977–78.

The plan of work that is to be further developed by the committee at the annual meetings includes professional training for work on less developed country (LDC) problems. The AAEA International Committee carried out an assessment of international training in agricultural economics in 1973–74 and published a monograph through the Agricultural Development Council. This assessment now needs updating. The committee has identified these issues: (*a*) a substantial decline in U.S. support for students from LDC's, (*b*) the need to make U.S. training programs more meaningful for foreign students from LDC's and to involve U.S. universities in a wider range of training activities, and (*c*) the need for increased support for graduate student and postdoctoral research by U.S. and LDC scholars on LDC problems.

The committee has under consideration a proposal for further study of these issues and the development of a training strategy to be presented and discussed at the 1978 annual meetings. This would require some funding support for a professional who would spend up to one-third time developing a training strategy and assisting in its implementation.

The committee will offer assistance in planning the program for the 1979 meetings of International Association of Agricultural Economists to be held in Canada. The committee has a special interest in a program activity dealing with professional training and related research.

Other activities include liaison with the Title 12 staff group, the BIFAD Board and the joint committees; a professional roster of individuals that are interested and available for international assignments (the committee plans to explore possibilities for improving the roster now available through the AAEA Employment Registry and coordinating this activity with other rosters being developed by the Agency for International Development, IADS and other international agencies); a historical review of the agricultural economics profession in international activities; and offering advice and counsel on the operation of the Agricultural Development Council/Research Training Network. Currently the international committee has been asked for suggestions on the implementation of a small grants research program.

Harold M. Riley, chairman

Report of the Resident Instruction Committee

The primary emphasis of the committee for 1976–77 pertained to developing a program for the Resident Instruction Session of the summer meeting, directing and coordinating the undergraduate activities of the AAEA, and considering program ideas that would be meaningful to members of resident instruction.

First, the program for the Resident Instruction Session. Our committee agreed to have an invited paper discussing the principles related to the teaching-learning process. We felt that one competent resource person with a background in education would be appropriate. Therefore, Dayton Roberts, professor of higher education, Texas Tech University, was selected to make the presentation. He will use approximately one-half of the session on the formal presentation dealing with aspects of

teaching and learning and the other half of the session will be allocated to group discussion.

The format of the undergraduate program is very similar to that used at the Pennsylvania State University meeting. Undergraduates may submit papers this year to either the "regular" instructional paper session or to a "special" undergraduate contributed paper session. It is felt that the special undergraduate paper session has a definite professional posture and one that is meaningful to those participating. The papers and oral presentation are, by the way, going to be evaluated, allowing for special recognition (certificates) to the participants that excel.

Other program ideas that might be meaningful to members of resident instruction have been discussed. For example, sharing of course outlines with our peers, sponsoring workshops, seminars, symposia, etc. We tried the symposia route this year with the industry group. Perhaps these other possibilities can be pursued in future years as felt needs exist.

Our committee has no recommendations for major changes. It likes the present format but continues to do fine-tuning to make the efforts of the committee and the AAEA more relevant.

Glenn C. Himes, chairman

Report of the Visiting Lecturer Committee

The committee continued to consider ways of improving the AAEA's services and communication with colleges and universities whose primary mission is undergraduate agricultural education.

Members located at such institutions suggested assistance with instructional programs would be of most help to them. Moreover, this assistance could take the form of a specially designed session at the annual meeting. As a partial response to these suggestions, members of the committee worked in cooperation with members of the Industry Committee and designed a symposium entitled "Agricultural Business Curricula and Industry Needs." The symposium is scheduled as one of the sessions at the 1977 AAEA-WAEA meeting, San Diego.

The Visiting Lecturer Program was announced in a presidential newsletter. One request was received. However, because of the nature of the request, we were not able to provide direct assistance.

William Herr, chairman

Report of the Extension Affairs Committee

The Extension Affairs Committee has planned and conducted two major activities during the past year. The first was a survey of extension economists. This survey was constructed so as to seek criticism and suggestions in three major areas of AAEA activity: the annual meetings, the *Journal,* and professional services. Questions were included that would elicit suggestions for improvement as well as shed light on problem areas. The survey questionnaire was sent to all economists in the several fields covered by the profession who had a half-time or more extension assignment. A response rate of slightly over 55% was obtained.

A full report of the results of the survey is not appropriate here, but a brief summary of some of the constructive suggestions are presented. The *Journal* and its policies need examination with respect to relevance to extension. There appears to be general consensus that rather little of the current content of the *Journal* is useful to extension or industry economists. If the *Journal* is to serve adequately this group of professionals, something must be done to encourage submission and publication of more applied research and methodologies that are useful in the "real world." Suggestions include a separate section of the *Journal,* a special issue of the *Journal,* or a new *Journal* for applied agricultural economics.

The AAEA should consider special sessions at the annual meetings for extension. Other suggestions included AAEA sponsored conferences or workshops for extension in subject matter areas.

The AAEA should promote and suggest mechanisms for increasing research-extension interaction and collaboration. It is felt that the estrangement of the two groups is largely due to a withdrawal of extension people from the affairs of the AAEA due to lack of useful services and to the growing gap in the nature of research being conducted and the applied nature of most extension problems.

The AAEA should examine the awards program for extension. The diversity of subject matter, approaches, etc., makes it a practical impossibility to single out one worker or one program worthy of recognition. The structure of the awards program, which is alleged to favor some situations over others, is also an issue.

A significant number of extension people do not feel that extension should be considered as a separate group. They express the opinion that to do so would be unwise for several reasons. Specific policies that create separate sessions, publications, etc., would tend to increase the divergence between research and extension. Several stated that they felt no discrimination and that good extension economists should find the content of the *Journal* or the annual meetings useful. A well-trained professional should not regard himself in the functional role but as an agricultural economist.

The preliminary results of the survey and recommendations were communicated to the Board at their meeting on 31 July 1977. The Board received the report with interest and appreciation. The Extension Affairs Committee was urged to develop the

report of the survey as a potential article for the *Journal* and to proceed with proposals for AAEA sponsored activities for economists employed by extension.

The second major activity of the committee was a symposium held at the San Diego meetings. Under the leadership of Charles Rust, a program was developed to address the issue of the activities and services of the AAEA and the expectations and needs of extension economists. Included were the report from the survey mentioned previously, reactor papers, and a response from a member of the Board.

As chairman of the Extension Affairs Committee, I would like to thank the following members for their able and willing assistance during the past year: Norbert Dorow, North Dakota State University; W. S. Farris, Purdue University; Fred A. Mangum, North Carolina State University; Gene Nelson, Oregon State University; Bobby H. Robinson, Clemson University; Charles H. Rust, Montana State University; William W. Wood, University of California, Riverside; W. Fred Woods, Extension Service, USDA; and Charles Covey, University of Florida (who helped with the survey even though his term on the committee had expired).

Robert L. Christensen, chairman

Report of the Contributed Papers Committee

The Contributed Papers Committee represents a new approach to managing the contributed papers program of the AAEA. By building on experience carried over by committee members, the program can be improved from year to year. Previously, except through committee reports, information about factors leading to strengths and weaknesses in the program was lost between years as contributed papers chairmen were changed. It is too early to assess benefits of the new system.

The committee developed and approved a statement on "The Role and Conduct of the Contributed Papers Session" (see appendix). The statement includes purposes of the contributed paper program, criteria for paper selection, and an evaluation form used by the review committees in 1977.

The call for contributed papers was distributed in December 1976 with the submission date moved forward to 1 April, compared with 1 May to 1 June in recent years. Approximately 200 papers were received. The program has fifteen contributed paper sessions, including five sessions with four papers and ten sessions with five papers. In addition, an alternative paper was chosen for each session. Thus, 85 of the 200 papers were accepted. The faculty of the Departments of Agricultural Economics at the University of Arkansas and Oklahoma State University served as reviewers.

Several innovations were tried this year. The alternative paper allows recognition of more authors and will facilitate the program in case some authors cannot give their paper. The authors and titles of alternate papers are in the annual meeting program and the abstracts will be in the *Journal*.

At the annual meeting, abstracts for each session will be available at the registration desk for review of the membership prior to the session. Hopefully, the opportunity to review the abstracts will help members choose sessions and know something about the content of concurrent sessions they must miss. Abstracts and surplus papers (we required that 50 be provided) will be made available after the contributed papers session as long as available.

The authors and session chairman have been given special instructions and admonitions designed to improve presentations and discussions. As we say in the Southwest (in good years), "The hay is cut and down in the field." We now must simply wait to see how the plans for the contributed papers program work.

The committee would like the reaction of the AAEA leadership to an effort to increase the stature and recognition of contributed papers. Specifically, we propose that a numbered series be considered along with a standard cover page. Each paper accepted would be assigned a number, and the author would be required to put the standard cover page on his paper. The paper could be cited by the AAEA contributed paper number. The numbering system could be very simple by years, e.g., AAEA Contributed Paper No. 77-1, 77-2; 78-1, 78-2. The source of papers would be at the home institution of the author as is now the case.

My year as chairman was made most pleasant by the cooperation of committee members and others. My colleagues at Oklahoma State University, Dan Badger and Harry Mapp, did an outstanding job on the program for 1977, and I appreciate it. Faculties at Oklahoma State University and the University of Arkansas were willing and conscientious reviewers. Ken Farrell was always on top of the situation, very helpful, and a pleasure to work with.

Odell L. Walker, chairman

Appendix: The Role and Conduct of the Contributed Papers Session

A primary purpose of the annual meeting of AAEA is to share the newest ideas and latest advances in the profession. Professional interaction at the national level is one way that goals of the profession can be advanced. Some papers at the annual meeting are invited. As a result, the topics and speakers for invited papers are understandably determined by the interests and knowledge of those who put the program together.

Addition of contributed papers to the program allows maximum participation by AAEA members in submitting papers and having a diversity of pa-

pers to hear and discuss at the annual meeting. A general call for contributed papers and the response by the membership constitutes a sampling of current efforts across the profession. The procedure is not selective with respect to authors or subjects but depends initially on the contributor's judgment as to the worthiness of his effort. Contributed papers give anyone with an idea or research results an opportunity for a forum before the AAEA. New and relatively unrecognized people in the profession have traditionally used contributed papers as an outlet for their research and their ideas. The opportunity to present a contributed paper encourages their attendance. These are the people most likely to be overlooked for the limited opportunities to present invited papers.

In summary, contributed papers (*a*) provide an opportunity to sample the latest ideas and advances in the profession, (*b*) provide an opportunity for new, lesser known members to participate on programs, (*c*) add diversity and variety to the program, (*d*) encourage attendance at the annual meeting, and (*e*) afford a competitive challenge to submit a paper and gain acceptance.

A sound and thoughtful review process is needed to preserve the benefits possible from contributed papers. The number of contributed papers received by the review committee has ranged from 120 to 200 papers per year. Program and space limitations for contributed papers may vary from year to year. Thus, the amount of screening necessary, beyond eliminating clearly unacceptable papers, also varies from year to year. In all cases, evaluation criteria are needed. The following criteria are recommended. (*a*) The paper should present material relevant to the agricultural economics profession. (*b*) The paper should present a strong new idea or contribution to the profession in the area of teaching, research, or extension. Reviewers' judgments concerning the overall contribution of the paper are needed. For example, the paper might be graded on a scale between outstanding and not acceptable, as illustrated by table 1. (*c*) Because of the nature of the program and the setting for the presentation, the contributor should demonstrate through his paper that he can communicate the idea within the twelve-page limit and the few minutes allowed for oral presentation during the meetings. In general, the quality of the communication will determine the success of the presentation.

The review form is designed to record judgments of the reviewers concerning the above criteria. At least three people read and review each paper as the basis for selection or rejection. As always, the success depends very heavily on the judgment of reviewers. The 1977 Program Committee (Walker, Badger, and Mapp) used the reviewers' evaluations directly in final selection of papers. Reviewers were also asked to classify the papers by topics to aid in forming sessions. Reviewers for 1977 included the faculty of Oklahoma State University supplemented by a group of faculty from the University of Arkansas.

Report of the Advisory Committee for the Census of Agriculture

During this year the committee held two meetings, both dealing mainly with review of progress in assembling and publishing the 1974 census and with plans for the 1978 census. As you know, the 1974 census of agriculture had more than its share of difficulties, many of which arose from indecision and bungling within the Bureau of Census. Fussing over the definition of a farm, poor planning and execution of enumeration, respondent resistance, budget and summarization problems within the Bureau, and problems with publication were among the difficulties that beset the 1974 census. Most of these difficulties have now been mitigated or resolved in some way so that state and county data are now being published on a belated schedule. The quality of data in the 1974 census of agriculture is probably the most questionable of any agricultural census in this century.

Plans for the 1978 census seem to be progressing much better than the 1974 experience. In the first place, the Bureau has no doubt that they will take a census in 1978. Since Congress changed the traditional dates of the census of agriculture, pointing toward a coordination of all economic censuses by 1982, the 1978 census is viewed as something of an interim or transitional effort. I think it fair to say that the Advisory Committee has urged the Bureau to "get through" the 1978 experience with something of a minimum effort while preparing for meaningful coordination with the other economic censuses by 1982. I think it fair also to say the Bureau is striving for the minimum effort without as yet preparing for the meaningful coordination. The 1978 effort is still viewed chiefly as a "census of farms" rather than a "census of agriculture."

Three topics seem uppermost in the minds of Bureau planners and crowd the agenda of the Advisory Committee. One relates to the development of complete mailing lists of farm operators. Defining and finding farm operators is certainly no easy task, and better cooperation between the Bureau and the Statistical Reporting Service would seem to be in order. Another topic relates to reducing respondent resistance, and this includes requirements for a preenumeration educational program, design and content of questionnaires, and follow-up tactics with nonrespondents. The third topic relates to design and content of questionnaires, including items of information needed from the primary enumeration versus items to be obtained from subsequent sample surveys. Needless to say, requests for information always exceed the reasonable capacity of an enumeration, and the Advisory Committee has

Table 1. Evaluation Form for Contributed Papers for the AAEA Annual Meeting

Manuscript Title:
Author(s):

1. Does this paper present material relevant to agricultural economics for the contributed papers sessions of the annual meeting of AAEA?

( ) Yes (does qualify) ( ) No (does *not* qualify)

2. This item is designed to determine the nature and degree of contribution of the paper and to elicit your overall evaluation.

a. Is the central focus of the paper oriented toward:

( ) Teaching ( ) Research ( ) Extension

b. Indicate the nature and degree of contribution:

Item	Degree of Contribution: Much	Some	Little	None
New or modified theory				
New or modified method				
First empirical application of a method				
Report of empirical work				
Review or appraisal				
Proposal for action				
Chronicle of profession				
Other (Specify) _____				

c. Circle the numerical value that reflects your overall evaluation of the paper (the attached "quality scale" may be useful to the reviewer):

Out-standing[a]	Very Important	Important	Average	Acceptable	Not Acceptable
100 95	90 85 80 75	70 65 60 55	50 45 40 35	30 25 20 15	10 5 0

3. Does the paper communicate effectively and offer strong promise as a stimulating presentation at the annual meeting?

( ) Yes (does qualify) ( ) No (does *not* qualify)

4. If acceptable, indicate the contributed paper session topic in which the paper would best fit. _____

5. If not acceptable, please give a brief explanation of the primary deficiencies or weaknesses._____

[a] Rating guide is: not acceptable: falls below 15 points; acceptable (rated 15–30): fills narrow blanks in an existing framework of knowledge; or corroborates ideas and theory; or modifies known concepts and techniques to deal with a new situation; or restates or reviews previously published viewpoints and empirical information with only minor additions to established knowledge; average (rated 30–50): falls between acceptable and important; important (rated 50–70): establishes new concepts or techniques in teaching, research, or extension that are of considerable interest and considerable value to economic scientists or the general public; or reviews, analyzes, and interprets knowledge of broad scope; or raises significantly new substantive issues (material in this class has a good probability of being cited rather frequently in similar papers by the authors and occasionally would be discussed in references covering similar subjects in either teaching, research, or extension); very important (rated 70–90): falls between important and outstanding; outstanding (rated 90–100): makes a major advance in knowledge and opens the way for extensive further developments by elaborating and/or solving a teaching, research, or extension problem of great methodological or policy importance to the profession or to the public (material in this class has a high probability of being discussed (not only cited) in literature reviews for a given field and would at least be summarized in any related references). (Rating guidelines with adaptation are from Bryon T. Shaw, *The Use of Quality and Quantity of Publication as Criteria for Evaluating Scientists*. Misc. Publ. 1041, ARS, USDA, Jan. 1967.)

spent a great deal of fairly unproductive time discussing who wants what in and in what detail.

Despite the size and complexity of the task of taking a "census of farms," planning for the 1978 effort seems to be going about as well as one might expect. The Bureau will probably use a schedule much abbreviated from the one used in 1974, it probably will differ by regions to avoid asking Michigan farmers about oranges and Florida farmers about cranberries, and it will be pretested widely. Plans for summarization promise more expeditious reporting than we have had in the last census.

I am disappointed that the Bureau has not yet made visible progress toward coordination of the economic censuses. I have suggested that this topic be placed high on the agenda of the Advisory Committee, but the Bureau people have not yet been prepared to discuss it. As AAEA representative on the Advisory Committee I have no specific recommendations for the president or the Board. I suggest that the subsequent AAEA officers plan to keep the same person on the Advisory Committee for several years because one's effectiveness grows with the length of tenure on the committee.

M. L. Upchurch, chairman

Report of the Agricultural Statistics Committee of Federal Statistics Users' Conference

This is the second year of operation of the FSUC Agricultural Statistics Committee after being reactivated in late 1975. During the first year of operation, committee objectives and operating procedures were established. The committee was formed to include a broad representation of data users. Meetings were held to establish contacts with representatives of major data producer and user groups.

The second year of operation has included the following activities. (*a*) A November 1976 committee meeting was held in Washington, D.C., in conjunction with the 20th annual meeting of the Federal Statistics Users' Conference. The committee reviewed government statistics activities with special emphasis on the census of agriculture. As a member of the Census of Agriculture Advisory Committee, I find it helpful to counsel with the FSUC Committee on areas of concern. (*b*) John Aiken and Norman Coats of the FSUC Agricultural Committee participated in the Agricultural and Rural Data Workshop sponsored by the AAEA Economic Statistics' Committee and major divisions of the USDA. (*c*) The FSUC Agricultural Committee held a one-day meeting in February 1977 with representatives of major user and producer groups from various branches of the federal government. The purpose of the meeting was to discuss data producer plans for the year ahead and to present data user requirements and suggestions for additions, deletions, and direction relative to federal statistics. These discussions are most helpful in building relationships for future discussions as the need for change arises.

Plans for 1977–78 include the following: expand the FSUC Committee to include certain key areas of data users not now represented, continue a committee awareness of data needs and make suggestions and recommendations as necessary, maintain contacts with other agricultural committees to determine future requirements for agricultural statistics, and hold a meeting in early 1978 with representatives of major user and producer groups from various branches of the federal government. At this full-day meeting producer plans and user requirements for statistics in 1978–79 will be discussed. Suggestions relative to future activities of the committee will be appreciated.

Norman M. Coats, chairman

Report of the Committee to Evaluate Annual Meetings Programs

Activities underway at the present time are the following. (*a*) A questionnaire was prepared and circulated to the current membership early in 1977. The returns are being tabulated and summarized. (*b*) A questionnaire was prepared and circulated early in 1977 to those who have recently dropped membership and for which a current address could be obtained. The returns are being tabulated and summarized. (*c*) A questionnaire that serves as the centerfold for the printed program has been prepared. Those attending the San Diego meeting are asked to complete the form and leave it at the meeting. Results will be tabulated and analyzed following the meeting. (*d*) The chairpersons for each of the sessions for the San Diego meeting are being provided with an evaluation form that they are asked to complete and turn in to the committee. (*e*) Members of our committee along with two assistants each plan to complete an evaluation form for each session for the San Diego meeting.

The committee will meet 31 July 1977 to review progress to date and make plans for completing analysis of data being collected and preparation of a report. The committee anticipates being able to make a comprehensive report to the Board at their January 1978 meeting.

H. J. Meenen, chairman

Report of the Alternative Publications Committee

The Alternative Publications Committee was appointed 11 February 1976 by President James Bonnen. The charge to the committee was "to examine possible publication formats and purpose, design some sort of alternative formats and test their potential for member support . . . , recommend a course of action to the Board for creating some alternative publication(s) to fulfill some of the currently unserved needs of the profession . . . , pay close attention to the question of how such publication would be financed and whether demands were sufficient to sustain the cost."

The committee was reappointed by President Farrell, 16 November 1976. In addition to the original membership, Fred A. Mangum and James M. Neilson were appointed to serve with the committee. The basic charge to the committee was to appraise publication services of the AAEA, present and potential, basically looking toward publications in addition to the *Journal*. Further, the committee was requested to obtain input from the membership of the AAEA re desired services, to study the experiences of other professional associations, and to share information and exchange views with other AAEA committees having activities related to those of the Alternative Publications Committee.

The committee met in St. Louis, Missouri, on 8 April 1977 to develop plans for completing the committee's responsibilities and to initiate action to develop the final report. The committee agreed that its main concern should be in keeping a high quality, scientific journal with no diminution in quality. Cost will continue to be a major consideration in

expanding the current publication offerings. Currently, the *Journal* cost is about $64 per page for 7,000 copies of a 160-page issue. The composition charge is $32 per page, and the basic printing charge is $25 per page. Mats, tables, and other special items increase the cost further. The only likely possibility for reducing the per page charge is in reducing the composition charge.

The committee delineated five alternatives in addition to the *Journal* as follows: a newsletter, split the present journal into a theoretical mathematical issue and an applied issue, a journal of economic literature, a separately priced supplement for the proceedings issue, and a publication modeled after *Challenge* to meet a completely different audience. The newsletter alternative and the separately priced supplement for the proceedings issue appear to be the only alternatives that could be published at a lower per page cost. (The composition charge could be reduced by utilizing camera-ready typewritten, rather than cold-type copy.) Since some of the material presently published in the *Journal* (minutes, news notes, etc.) could be published in the lower cost newsletter, either the number of pages in the *Journal* could be reduced or additional pages made available for articles through adoption of this alternative. Arguments pro and con for each alternative as well as results of member reactions are being prepared.

A questionnaire developed by Paul Nelson and reviewed and revised by the committee was included in the late May/early June mailing to the membership to obtain their views about the alternatives delineated. To date, over 400 questionnaires have been returned, and the preliminary analysis is completed.

Plans now are to complete a preliminary draft of the committee's final report prior to the San Diego meetings, to revise the report with the committee membership at the annual meetings, and to submit a final report to the board including recommendations as soon as possible.

Verner G. Hurt, chairman

Report of the Committee on *Journal* Page Charge

The committee was asked to review the statement of policy and the administration of the page charge and to consider two recommendations of the Professional Activities Committee to the effect that (*a*) nonmembers be assessed a page charge of $75 on articles accepted for publication in the *Journal* and (*b*) that a submission fee accompany all refereed papers submitted to the *Journal*. In addition, the committee was asked to consider a suggestion that at least one author of articles accepted for publication in the *Journal* be a member of the AAEA.

Recommendation 1: The statement of policy with respect to the page charge should be changed. A final rule relative to the page charge and second class mailing privileges was published in the *Federal Register*, vol. 42, no. 103, 27 May 1977. The specifications of the final rule may be summarized as follows. "Voluntary" page charges that are "truly voluntary contributions" do not come within the specifications for advertising. The current page charge statement cannot be deemed voluntary (though in practice payment of charges is not a prerequisite for publication). Material published pursuant to a nonvoluntary page charge policy must be marked with the word "advertisement" on the first page of the article. The word "advertisement" must "be in bold or italicized print, or otherwise given emphasis so it can be plainly seen."

The committee considered three alternatives: (*a*) the loss of second class bulk mailing privileges representing approximately $5,000 in additional mailing costs; (*b*) no change in the current statement and a footnote on the first page of each article for which the page charge is honored, which would read "A page charge, to defray in part the cost of producing this article, has been paid to the American Agricultural Economics Association in accordance with established procedures for publication of materials herein; for the limited purpose of complying with regulations of the U.S. Postal Service the article is deemed an *advertisement*" (this alternative requires a change in administrative procedures so that a determination of whether or not the page charge will be honored can be made before the preparation of galley proofs); and (*c*) a change in the policy statement regarding page charges to read "Contributions published in the *Journal* are subject to a page charge of $40 per printed page, or fraction thereof, payable by the supporting institution or granting agency. Exemptions are granted for book reviews, the presidential address, fellows lecture and those invited addresses and papers receiving explicit written exemptions from the AAEA president. Payment of this page charge is not a prerequisite for publication. Instructions for making payment and for requesting an exemption are provided with galley proofs. If the page charge is honored 100 reprints are provided." This wording is identical in all substantive aspects to the statement in the *Journal of the American Statistical Association*.

The committee recommends the adoption of alternative (*c*) on the grounds that the labeling of scholarly papers as advertisements, even in a footnote, is inappropriate and the proposed change in the policy statement is consistent with the administrative procedures currently utilized with respect to the page charge.

Recommendation 2: The page charge for nonmembers should be the same as for members. Based on six issues, August 1975 to November 1976 inclusive, 82% of the pages eligible for page charges were by members and for 90% of those, the page charges were honored. Eighteen percent of the

pages were authored by nonmembers; of those, the page charges were honored for 45%. Authors with foreign addresses produced about 12% of the eligible pages. Of those pages, the page charges were honored on 36%, and all of those honored were by members.

Assuming 660 pages per year are eligible for page charges, that the distribution between member and nonmember authored pages remains as in the 1975–76 period, and that a $75 page charge would not diminish the number of nonmembers honoring the page charge, the increase in AAEA income resulting from the higher page charge for nonmembers would be less than $1,900. On the other hand, if it resulted in nonmember authors joining the AAEA to avoid the price discrimination, the increased income would be in the order of $200. Balanced against this are the increased difficulty and costs of administering the page charge. The membership list changes continually throughout the year. The membership list is maintained in the office of the secretary-treasurer, while the billing of page charges is handled by the editor's office! While these difficulties can be overcome at some cost to the AAEA, the potential income benefits do not seem to justify a discriminatory page charge for nonmembers.

Recommendation 3: A submission charge should not be levied on articles submitted for publication at this time. The benefits of a submission fee appear to be relatively modest. At the same time, an additional administrative burden would be placed on a new editor. However, if future financial conditions require additional income, a submission fee is a potential source of a modest increase in income. The current editor estimates that the costs for postage, mailing, and secretarial time for the review process is in the $15 to $20 range per submission. A $15 submission fee would recover most, if not all, of these costs. With about 300 submissions per year, the potential income would be about $4,500. Further, such a charge might encourage some authors to give more consideration to the decision to submit a manuscript.

Recommendation 4: Membership in the AAEA by at least one author should not be a condition for acceptance of an article for publication. The benefits resulting from publication of an article accrue both to the author and to the members who utilize the article in their work. The major function of the *Journal,* however, is to provide a high quality service to the membership. It is our view that the quality of the contribution should be the single criterion for publication decisions.

Lee M. Day, chairman

Minutes

Minutes of the Executive Board Meeting, Washington, D.C.

The meeting was called to order by President Farrell at 8:30 a.m., 3 January 1977.

Present: Voting Members:
Farrell, Bonnen, Barr, Crowder, Stanton, Lane, Mangum, Hildreth, Raup
Members ex officio:
Redman, Tomek, Ball
Guests:
Martin, Holt, Lee, Rasmussen, Mather, Boyne, Wunderlich, Witt, Worden

1. Farrell reviewed the agenda and stated that in accordance with revisions of bylaws all motions should be prepared in writing by the maker and that Bonnen will be responsible for incorporating all policy actions in the bylaws. Redman will have an updated set of governing regulations ready each meeting.

2. Farrell reviewed the committee appointments and some problems in selecting committees.

3. Stanton moved that the minutes of the Pennsylvania State University meeting be approved. Seconded. Passed.

4. Holt presented the final report on the meeting held at Pennsylvania State University. The need for a policy statement on financial arrangements between the AAEA and host institution was noted. Lane moved that the report be accepted with thanks and that Redman prepare a policy statement on how the potential surplus or deficit may be shared. Seconded. Passed.

5. Redman reported as secretary-treasurer.

6. Stanton reported briefly for the Finance Committee. Since the financial records of the AAEA are audited by a certified public accountant, there appeared no real need for an Audit Committee. Stanton moved to recommend to members at the next annual business meeting that the Audit Committee be eliminated and the bylaws amended accordingly. Seconded. Passed.

Stanton reported on the possibility of obtaining professional management for the AAEA's investments. Those contacted suggest that the minimum fee will run from $1,400 to $1,700 per year. Since it was uncertain whether benefits would cover the cost, the question was referred back to the committee for further study. The committee was instructed also to explore no load mutual funds for external management and to develop two or three alternatives for internal management.

7. Lee reported for the Membership Committee, setting forth plans for more effective recruitment.

8. Tomek reported as editor.

9. Redman reported on the progress of the *Handbook-Directory,* indicating it would be ready for the printers by 1 February. Lane moved that 7,500 copies be printed. Seconded. Passed.

10. Barr reported on the printing contract. Previously, the Executive Board had voted to award the contract to Edwards Brothers contingent on satisfactory negotiation on several items, particularly reprint costs. Because of a change in Heffernan's billing procedures for author's alterations and being unable to work out fully the contingencies with Edwards Brothers, it was decided to remain with Heffernan. Crowder moved that the print order for each issue of the *Journal* be set at 500 copies more than the AAEA membership as of 31 December or the membership at the time the print order is placed, whichever is greater. The intent is to have an inventory of 500 copies after the distribution to membership. Seconded. Passed.

11. Rasmussen reported on the literature retrieval activity. It was suggested that an item be inserted in a presidential newsletter indicating the university or agency and the number of citations submitted to the system.

12. Mather and Boyne reported for the Employment Committee and Professional Registry Committee, proposing a revised proposal for a computer-based employment system to the U.S. Department of Labor seeking to extend the project for one additional year with final additional funding of $32,800. Lane moved to approve the submission of the proposal to the U.S. Department of Labor and authorize the president to sign the proposal for the AAEA if there are no substantial modifications after a conference with the U.S. Department of Labor. Seconded. Passed.

13. The Professional Registries Committee recommended that the Board (*a*) take action declaring intent to enter into agreement with the Economic Research Service to operate a Registry for Agricultural Economists with the condition that a plan be developed to generate the AAEA's share of costs, (*b*) authorize the Professional Registries Committee to solicit commitments to fund the AAEA's share of project costs, (*c*) approve submission to the U.S. Department of Labor of a new contract proposal to provide a final year's funding of the Registry by the Employment Service, U.S. Department of Labor, and (*d*) continue to explore through the Professional Registry and Employment Service Committees the possibilities of U.S. Department of Labor support for the Registry on a continuing basis. Hildreth moved that items (*a*) through (*d*) of the report be approved. Seconded. Passed.

14. Ball reported for the Awards Committee and presented a proposal to establish a new AAEA award, Distinguished Policy Contributions, which may be granted annually beginning in 1978 for contributions to the advancement of public understanding of major issues related to food and agriculture, including natural resources and rural areas. Raup moved that the AAEA establish a Public Policy Award and that the Awards Committee be instructed to draft a revised description for announcement in fall 1977. Seconded. Passed.

15. Ball, on behalf of the Awards Committee, presented a slate of possible AAEA nominees for the Edward W. Browning Award of the American Society of Agronomy. The president was instructed to forward the nomination of Earl O. Heady, Iowa State University.

16. Possible nominations for the Alexander von Humboldt Foundation Awards were discussed. No nominations are to be forwarded by the AAEA in 1977.

17. Wunderlich reported for the Professional Activities Committee and presented a policy statement relating to AAEA sponsorship and endorsement of professional activities under conditions where the AAEA is involved in the planning, conduct, and evaluation in the interest of a significant proportion of the membership or a recognized subset thereof. Proposals are to be submitted to the president, who shall in turn seek the advice of the Professional Activities Committee. Hildreth moved that the report be adopted in principle and that it be studied again and possibly revised considering the suggestions and comments made. Seconded. Passed. (Note: A copy was sent to the membership in March 1977.)

18. Witt Reported for the Committee to Evaluate the Annual Meeting, summarizing the plans for a survey of members' and nonmembers' opinions regarding the annual meetings and also for a centerfold questionnaire for the printed program of the San Diego meeting.

19. Worden reported briefly for the Economic Statistics Committee.

20. Hildreth moved that the AAEA president prepare a foreword, if requested, for a forthcoming book of Fred Waugh's writings in cooperation with the Economic Research Service and Martin Abel et al. of the University of Minnesota. Seconded. Passed. The Board also approved the establishment of an AAEA ad hoc editorial committee, if requested, to work with Abel et al. in preparing the book. These motions do not imply any availability of AAEA funds for the effort.

21. Stanton moved that a special committee be appointed to prepare the text for a four-page printed brochure describing employment opportunities and careers for graduates in the field of agricultural economics. Seconded. Passed.

22. A proposal from J. C. Headley, University of Missouri, that the AAEA request CAST to develop a task force to study methodologies associated with estimation of costs and benefits of pesticides used in agriculture was reviewed and rejected.

23. In an executive session, the Board selected V. James Rhodes and Stanley R. Johnson of the University of Missouri as *Journal* editor and associate editor, respectively, for a three-year term beginning with the February 1978 issue. Eight persons had been nominated for consideration.

24. In an executive session, the Board reviewed the nominations for AAEA fellows. Eight nominations were forwarded to the Fellows Election Committee.

25. A letter from Marion Clawson, Resources for the Future, proposing that the AAEA undertake surveys of its members regarding agricultural policy issues was discussed. No action was taken.

26. Redman was instructed to review the offer of Iowa State University to include AAEA documents in the Iowa State University archives.

27. Farrell and Redman presented an outline of the program, arrangements, and preliminary budget for the AAEA-WAEA meeting to be held in San Diego, California, 31 July–3 August 1977.

28. Lane moved that a special committee be appointed to review the management methods and procedures of the AAEA and make recommendations to enhance efficiency in operations. Seconded. Passed.

29. Board adjourned at 4:00 p.m., 4 January 1977.

Respectfully submitted,
John C. Redman
Secretary-Treasurer

Minutes of the Executive Board Meeting, San Diego, California

The meeting was called to order by President Farrell at 8:05 a.m., 30 July 1977.

Present: Voting Members:
Farrell, Hildreth, Barr, Crowder, Stanton, Lane, Mangum, Raup, Bonnen
Members ex officio:
Redman, Tomek, Storey
Guests:
Sundquist, Forker, Day

1. Farrell reviewed the agenda for the Board and the procedures to be followed during the annual meeting. He emphasized that since the program was tightly scheduled all sessions should begin on time and end on time. Farrell also explained procedures for implementing the policy of requiring membership in the AAEA as a condition for participating in the program.

2. Redman reported on registration, indicating that 779 had preregistered and that over 200 addi-

tional members were expected to register. All arrangements seemed to be ready for the meeting.

3. Lane moved that the minutes of the Board meeting held in Washington on 3–4 January 1977 be approved. Seconded. Passed.

4. Farrell read the report of the tellers indicating that B. F. Stanton was elected as president-elect and Joseph Coffey and Edward Schuh were elected as directors. He also announced that Lowell Hardin, A. C. Hoffman, Sidney Hoos, and Earl Swanson will be installed as fellows.

5. Redman presented the secretary-treasurer's report, which will be given at the general business session (see committee reports).

6. Redman transmitted the report of the audit conducted by the certified public accountant. After a review, Stanton moved the acceptance. Seconded. Passed.

7. Redman reported for the *Handbook-Directory* Committee, indicating that it was mailed to all members and subscribers in February 1977 and single copy sales were not great. The committee has completed its assignment.

8. Stanton reported for the Finance Committee in two segments. One segment dealt primarily with plans for monitoring expenses and development of guidelines for handling cash flow by the secretary-treasurer. This involved following closely each of the major enterprises of the AAEA by a member of the committee and suggesting some maximum balances in individual accounts in the bank. Lane moved that the guidelines be adopted in principle. Seconded. Passed.

The second segment dealt with management procedures of the AAEA portfolio. The committee recommended a combination of internal and external options. The procedure would involve specification of goals concerning desired performance of the portfolio, periodic reviews by a brokerage house or investment service holding the account, and implementation of any recommendations concerning changes in the portfolio suggested by a committee of AAEA members. The recommendations of the Finance Committee with explanatory materials will be forwarded to all Board members and will be implemented with agreement of two-thirds of Board members. A Board member will have two weeks to indicate a negative response; otherwise, a positive response will be assumed (see committee reports). Hildreth moved to adopt the report on management of the AAEA portfolio with modifications as suggested by Crowder and Lane. Seconded. Passed.

9. Redman reported for Publication of Postwar Literature Review Committee. Publication of volume II is scheduled for December 1977. The publisher has taken steps to expand sales outside the United States, and the AAEA has sent materials to members informing them of special purchase price.

10. Day reported for the Page Charge Committee, which examined recommendations that nonmembers be assessed a page charge of $75 for published articles and that a submission fee accompany all refereed papers submitted (see committee reports). The committee recommended that the page charge for nonmembers be the same as for members and that a submission charge not be levied at this time. In addition, the committee recommended that membership should not be a condition for acceptance of an article for publication in the *Journal*. The committee examined at length the policy and administration of the current page charge relative to the regulations of the U.S. Postal Service. The committee considered three alternatives: (*a*) the loss of second class mailing privileges, which would add approximately $5,000 to mailing cost; (*b*) no change in current statement but, as required in postal regulations, add a footnote on the first page of each article for which a page charge is honored that would read: "A page charge, to defray in part the cost of producing this article, has been paid to the American Agricultural Economics Association in accordance with established procedures for publication of materials herein; for the limited purpose of complying with regulations of the U.S. Postal Service the article is deemed an *advertisement*"; (this alternative would require a change in administrative procedures to determine whether or not the page charge will be honored before preparation of galley proofs); and (*c*) change the policy statement to read: "Contributions published in the *Journal* are subject to a page charge of $40 per printed page, or fraction thereof, payable by the supporting institution or granting agency. Exemptions are granted for book reviews, the presidential address, fellow's lecture, and those invited addresses and papers receiving explicit written exemption from the AAEA president. Payment of this charge is not a prerequisite for publication. Instructions for making payment and for requesting an exemption are provided with galley proofs. If page charge is honored, 100 reprints are provided." After considerable discussion, Lane moved that the third alternative be adopted. Seconded. Passed.

Stanton moved the recommendation that the page charge be the same for nonmembers as for members be adopted. Seconded. Passed. No action was taken on the recommendation that no submission charge be levied. No action was taken on the recommendation that membership in the AAEA by at least one author should not be a condition for acceptance of an article for publication.

11. Tomek reported as editor (see committee reports).

12. Rhodes, reporting as incoming editor, indicated that he was receiving papers and that the policy and procedures would be essentially the same as under the previous editor. The Board offered no specific directions except to encourage the new editor to seek commission of papers, invite papers, etc.

13. Tweeten reported for the Statistics Committee, recommending the approval of two task forces

to lay out the conceptual framework and operational guidelines for determining the economic value of statistical information and on measuring agricultural productivity. Stanton moved that these two task forces be commissioned. Seconded. Passed.

The committee recommended an ad hoc task force on survey of agricultural and food outlook to investigate the feasibility of periodic surveys of specialists to evaluate their forecasts and to disseminate the results in a suitable manner. Stanton moved that the Statistics Committee be encouraged to appoint such a task force. Seconded. Passed.

The committee also proposed the appointment of a statistics editor for the *Journal*. The Board took no action except to encourage the chairman of the Statistics Committee and the new editor to work together on emphasizing the need for articles and other materials for the *Journal* concerned with new and old statistical series and their evaluation.

14. Barkley reported for the Professional Activities Committee, recommending (*a*) that the visiting lecturer program and committee be discontinued unless suitable funding can be found; (*b*) that a program committee be established to assist in planning content of the annual meeting; and (*c*) that the Professional Activities Committee have one of its members on the Alternative Publications Committee and on the Industry Affairs Committee. Hildreth, as new president, indicated that he planned to implement these recommendations unless objections are raised.

The committee was encouraged to work with the editor on the need for recommended commissioned articles on (*a*) accreditation and certification of agricultural economists; (*b*) the AAEA: a federation or guild; (*c*) keeping up with expanding boundaries of economic knowledge; and (*d*) complexity of present information systems. The committee was encouraged also to pursue further the National Science Foundation's "Science for Citizens" program.

15. Sundquist reported for the Committee on Management, Structure, Methods, and Procedures, summarizing the proposed plan of activity. By consensus, the Board accepted the report.

16. Boyne reported for the Professional Registries Committee, recommending (*a*) that the president, on behalf of the AAEA, enter into an agreement with the Economic Research Service to operate a Registry for Agricultural Economists. (As a first step, it is assumed that the president would designate an AAEA committee to work with ERS personnel in developing the terms and conditions of the agreement.) Stanton moved the approval of the recommendation. Seconded. Passed.

(*b*) That an AAEA committee be designated to represent the AAEA in carrying out the terms of the agreement. (It is assumed that one of the terms of agreement would call for an AAEA committee to advise the ERS on matters related to the operation and further development of the Registry.) Mangum moved the approval of this recommendation. Seconded. Passed.

(*c*) That the AAEA president be authorized to communicate in writing the Board's decision to consummate an agreement with the ERS to each organization that has made a commitment of funds and to confirm the amount of commitment made by the respective organization or individual. Barr moved the approval of this recommendation. Seconded. Passed.

17. Mather reported for the Employment Services Committee, indicating that the final funding period of the U.S. Department of Labor contracts will expire on 15 February 1978 and that arrangements for finance and funding of the Registry after expiration are being developed by the Professional Registries Committee.

The committee recommended that the next *Handbook-Directory* be prepared from the Registry and that necessary steps be taken to effect this change, i.e., determine the content of the biographical sketches and program the necessary changes in computer format. The estimated one-time reprogramming cost is $1,400, and direct computer and labor charge is under $450 per Directory to prepare a camera-ready copy for directory printing. Hildreth moved to authorize the Employment Services Committee to reprogram the Registry for multiple purpose uses, e.g., *Handbook-Directory*, with the contract funds available. Seconded. Passed.

18. Hildreth moved the dissolution of the Employment Services and Professional Registries Committees and the establishment of an Employment Services and Professional Registries Committee. Seconded. Passed.

19. Hurt reported for the Alternative Publications Committee, indicating the nature of study underway. Redman presented a brief report on the possibilities of using microform to capture the contributed papers and symposia at no cost to the AAEA. He also presented a possibility of publishing on demand through the use of microform to supplement the present *Journal*. No action was taken.

20. Rasmussen reported for the Literature Retrieval Committee, recommending that the committee be extended as presently constituted for another year, that the budget be approved and serious consideration be given to an additional sum of $12,000 to hire an additional person, and that the Board endorse further explorations with the Canadian groups and WAERSA to achieve further coordination of the information retrieval programs. Motion was made to extend the committee for another year, to approve the budget without the additional $12,000, and to encourage explorations with other groups. Seconded. Passed.

21. Trelogan reported for the Review of Fellows Selection Committee, making some recommendations to assure that all agricultural economists be

considered. Trelogan will work with Bonnen to formulate a policy statement.

22. Lee reported for the Membership Committee, indicating the nature of the organization set up and the plans underway to increase the membership in the AAEA.

Note: The following minutes were kept by V. James Rhodes while the secretary-treasurer was attending to registration and arrangements for the annual meeting.

23. Riley reported for the International Committee. The Board informally encouraged the committee to proceed on its plans.

24. Gerke reported for the Industry Affairs Committee. The Board informally encouraged the committee to proceed on its plans for facilitating industry speakers for university seminars.

25. Walker reported for the Contributed Papers Committee. It was suggested that the committee coordinate with the Alternative Publications Committee on their proposal of a numbered series for contributed papers.

26. Himes reported for the Resident Instruction Committee. The Board asked the committee to consider (in conjunction with other appropriate committees) the possibilities of the AAEA developing services to appeal to B.S.-level graduates in agricultural economics.

27. Herr reported for the Visiting Lecturer Committee. Hildreth moved the discontinuance of the Visiting Lecturer Committee and that the president be instructed to appoint an ad hoc committee to explore ways for the AAEA to serve agricultural economists in the non–land grant colleges. Seconded. Passed.

28. Ball reported for the Awards Committee. Motion was made by Stanton to approve the description of the award for the distinguished policy contribution. Seconded. Passed. The Board informally approved the statement that membership in the AAEA is not prerequisite to receipt of AAEA awards.

29. Coffey reported on plans for the meetings to be held on 6–9 August 1978 at Virginia Polytechnic Institute and State University at Blacksburg, Virginia. Hildreth moved that the differential in registration fees for the 1978 meetings at Virginia Polytechnic Institute and State University continue to be $25.00 ($12.50 for students) for those who are not members of either the AAEA or CAES. Seconded. Passed.

30. Hildreth reported on plans for the 1978 program. A program committee is planned to meet for 1-½ days on 20–21 December in Chicago. The committee will include those Board members who wish to be included plus a few others. The Board will meet on 27 December at the Allied Social Sciences meeting in New York.

31. Eckert reported as ASA-AAEA liaison representative. The suggestion of a multidisciplinary research award was referred to Awards Committee for consideration but that it include more than agricultural economics and agronomy. Eckert was encouraged to explore the possibilities of a symposium that he might then take to the Professional Activities Committee and to develop a proposal for a joint session with other disciplines at the annual meetings.

32. Christensen reported for the Extension Affairs Committee.

33. Schuh reported on his liaison contact with the National Bureau of Economic Research.

34. Bonnen moved a resolution on the fellows issue. (*a*) A Board Advisory Committee on Fellows Nominations shall be established from the Board to examine the lists of members of the AAEA to assure that members deserving of consideration as fellows not be overlooked and to examine the nominations received from the membership in order to advise the Board on the eligibility and the membership status of the candidates. (*b*) The committee shall consist of two members of the Board plus the secretary-treasurer. The secretary-treasurer should be prepared to report on the membership status of the candidates. The other two members, each serving two-year terms, are to be chosen by the president. (*c*) The committee shall transmit its findings to the Board by the time of the summer meetings. Thus, individual Board members will have this information for consideration before they meet in the winter to choose the nominees for forwarding to the Fellows Election Committee. Seconded. Passed. Schuh was appointed for a two-year term and Crowder for a one-year term.

35. Bonnen presented a draft modification of existing bylaws to reflect the last two years of Board actions. The Board approved modifications and/or additions to Bylaw Articles V, VIII, X, XII, and XIV. Bonnen proposed that a separate document entitled Policy Actions of the AAEA Executive Board be established to enroll the remaining policy actions of a continuing nature that the Board deemed not to belong in the bylaws. Seconded. Approved. Updated bylaws and a current copy of the enrolled policy actions will be provided the Board at its winter meeting each year.

36. Lane moved to accept the secretary-treasurer's report. Seconded. Passed.

37. The Finance Committee presented a proposed 1978 budget. Stanton moved that annual editorial support be raised to $22,500. Seconded. Passed. Barr moved a budget item of $15,000 for 1978 for Employment Committee agreement with the ERS. Seconded. Passed. Stanton moved to increase the secretary-treasurer's honorarium to $5,000. Seconded. Passed. Crowder moved the approval of the 1978 budget as amended. Seconded. Passed.

38. Hildreth discussed the 1977 winter program and discussed Board representation on various committees.

39. Farrell expressed appreciation to the Board

and especially to the departing Past-President Bonnen and the two departing Board members Mangum and Stanton. However, Stanton will be returning as president-elect.

40. Meeting adjourned at 5:35 p.m. on 31 July 1977.

Respectfully submitted,
John C. Redman
Secretary-Treasurer

Minutes of the Annual Business Meeting, San Diego, California

The 66th annual meeting was called to order by President Kenneth R. Farrell on 2 August 1977 at 11:15 a.m.

1. President Farrell presented for approval the minutes of the annual business meeting held at State College, Pennsylvania, 17 August 1976, as published in the proceedings issue of the *Journal*. Motion was duly made. Seconded. Passed.

2. Farrell announced officially the results of the election of officers. Bernard F. Stanton was elected president-elect, and G. Edward Schuh and Joseph Coffey were elected directors.

3. President Farrell highlighted the activities of the AAEA during the past years. (*a*) The affairs of the AAEA are conducted in large part through its committee structure. Currently, there are fifteen standing committees, seventeen special committees, three ad hoc committees, and six liaison representatives to other organizations, involving nearly 260 members. (*b*) An ad hoc committee was created to review policies and procedures concerning the *Journal* page charge. A special committee on business organization and management was created with the responsibility of reviewing the management structure, methods, and procedures of the AAEA and recommending steps that might be taken to improve effectiveness of operations and managerial processes. (*c*) V. James Rhodes and Stanley Johnson were selected as editor and associate editor, respectively, effective with the February 1978 issue of the *Journal*. (*d*) The *Handbook-Directory*, totaling over 600 pages, represents an important personal contribution of John Redman and Willetta Hager. (*e*) Volume I of *A Survey of Agricultural Economics Literature* appeared in February and volume II will be produced in late fall of 1977. (*f*) The Professional Registry has been financed solely by grants from U.S. Department of Labor. The Board has approved a plan whereby the Registry will be housed in the USDA (ERS) and be financed by annual grants from institutions that might use the services. (*g*) The Board has established a new Distinguished Policy Contribution Award, which may be awarded annually beginning 1977–78. (*h*) A policy statement has been adopted to encourage AAEA sponsorship of seminars, workshops, symposia, colloquia, and other professional activities. (*i*) No major difficulty has been experienced in following the policy to limit membership on committees and presentation and/or discussion of papers to members only unless waived by the president. (*j*) Membership has been maintained or increased in some categories; given the higher dues and the one-time membership increasing effect of the *Handbook-Directory* in 1976. (*k*) Upon recommendation of the Finance Committee, the Board has established guidelines for cash flow and account transactions in the secretary-treasurer's office. With specific financial objectives, the management of the portfolio will be vested with the Board with periodic reviews by an outside firm. (*l*) Other activities include work by various committees, some of which have been accepted and will become visable in the years ahead.

4. Redman presented the secretary-treasurer's report for fiscal year 1 January 1976 through 31 December 1976. Redman also presented a report on AAEA investments for 1976. Motion was made to receive the report. Seconded. Passed.

5. Stanton reported on the budget that was adopted by the Board for 1978.

6. Farrell presented the report of the certified public accountant on the financial condition of the AAEA. Motion was made to accept the report. Seconded. Passed.

7. Tomek reported as editor of the *Journal*. The report was accepted.

8. No old business was noted.

9. As an item of new business, Farrell presented a proposal to discontinue the Audit Committee since the AAEA is now using and plans to continue the services of a certified public accountant. Motion was duly made to amend the bylaws to discontinue the Audit Committee. Seconded. Passed.

10. Bonnen presented two resolutions: to express the appreciation to William Tomek and Cornell University for the services he rendered as editor and to express appreciation to John Redman and Willetta Hager for production of the *Handbook-Directory*. With no objections, copies will be sent to appropriate people.

11. Farrell announced the dates of future AAEA meetings. On 6–9 August 1978, the AAEA will meet at Blacksburg, Virginia; 29 July–1 August 1979 at Pullman, Washington; and 27–30 July 1980 at Urbana, Illinois.

12. Farrell commented on the meeting in San Diego, noting that this was the first time in over 40 years the AAEA has met in commercial facilities. The task of organizing the meeting fell on many people, particularly his secretarial staff—Mildred Evano, Carol Kotch, Sharon Warwick, and Geneva Riddle. Loyd Martin of the ERS worked hard in carrying out decisions with respect to travel, program, lodging, and committee activities. John Redman, in addition to regular duties, assumed responsibility for publicity, printing of program and brochures, catering arrangements, registration, and

a host of other duties. Pat Potter and the staff of the Town and Country Hotel were efficient, professional, and responsive to our needs. The Convention Bureau and the Pacific Telephone provided much appreciated assistance.

13. Farrell expressed appreciation to retiring Board members, Bernard Stanton and Fred Mangum and past president, James Bonnen, and turned the chair over to R. J. Hildreth, who became president.

14. Hildreth announced the date of the Allied Social Science Associations meeting in New York on 28–30 December 1977 and reviewed the program. He announced the Nominating Committee with Kenneth Farrell as chairman.

15. Meeting adjourned 12:30 p.m.

Respectfully submitted,
John C. Redman
Secretary-Treasurer

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